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ABSTRACT

To determine trained manpower needs and training resources in the clean water field, data were gathered from interviews with state and federal agencies as well as the Water Pollution Control Federation, from prior manpower reports, and from Bureau of Census employment data. After analysis of present manpower resources and future requirements, educational and training needs, training programs and opportunities, and personnel utilization and recruitment it was concluded that: (1) Total industry and government demands for engineers and scientists will probably exceed the supply for the next several years, (2) There is a continuing need for upgrading and updating professional skills through short-course training, and (3) Existing programs for the training of sewage treatment plant operators are inadequate in both quality and quantity. Some corrective actions to be effected by the Federal Water Pollution Control Administration (FWPCA) include: (1) continue FWPCA financial support of programs for training graduate students in specific water pollution control disciplines, (2) encourage and assist states in placing greater emphasis on training, and (3) improve the conditions of employment for operators of waste treatment plants. (SB)

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90TH CONGRESS
1st Session

SENATE

DOCUMENT
No. 49

MANPOWER AND TRAINING NEEDS IN WATER POLLUTION CONTROL

REPORT

OF THE

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

TO THE

CONGRESS OF THE UNITED STATES

IN COMPLIANCE WITH

PUBLIC LAW 89–753

AUGUST 2, 1967

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SENATE RESOLUTION 158

Submitted by Mr. Randolph of West Virginia

IN THE SENATE OF THE UNITED STATES,
Agreed to August 31, 1967.

Resolved, That there be printed as a Senate document the report "Manpower and Training Needs of the States and of Local Governments in Water Pollution Control", of the Secretary of the Interior, in compliance with the provisions of Public Law 89–753, the Clean Water Restoration Act of 1966; and that there be printed two thousand five hundred additional copies of such document for the use of the Committee on Public Works.

Attest:

FRANCIS R. VALEO,
Secretary.

ARCHIVES

CONTENTS

	Page
Foreword	v
Part I. The report in brief	1
The national investment	1
The personnel equation	1
Current use of training resources	2
Recruitment, retention, and utilization	4
Action programs	4
Part II. Manpower	7
Present resources and future requirements	7
Professional employees	8
State agencies	8
Local agencies	10
Industrial waste treatment	10
Equipment and chemical suppliers	11
Consulting engineers	11
Technicians	11
State agencies	12
Local agencies	12
Industrial waste treatment	12
Equipment and chemical suppliers	12
Consulting engineers	12
Sewage treatment plant operators	13
State agencies	13
Local agencies	13
Industrial waste treatment	14
Total manpower needs	14
Table I.—Estimates of manpower requirements	15
Part III. Educational and training needs	17
Professional employees	17
Formal training	18
Short-course training	19
Technicians	19
Formal training	19
Short-course training	19
Sewage treatment plant operators	20
Formal training	20
Short-course training	20
Part IV. Training programs and opportunities	23
Professional employees	23
Formal training	23
Short-course training	25
Technicians	26
Formal training	26
Short-course training	30
Sewage treatment plant operators	31
Formal training	31
Short-course training	31
Part V. Personnel utilization and recruitment	33
Salary and merit system coverage	33
Licensing of plant operators	33
Employee productivity	34
Continuing statistical needs	34
Pending Federal legislation	34
Part VI. Conclusions and corrective actions	37
Appendix A. Sources of data	39
Appendix B. Federal assistance to education and vocational training	44
Appendix C. Schedule of courses	48

FOREWORD

The true strength of a nation rests in its people. Their imagination, ingenuity, and skill have given us an incomparable establishment for the national defense, world leadership in agriculture, and outstanding capabilities in almost every aspect of construction, industry, and space exploration. We have the demonstrated capabilities and the resources to build superior ships, machines, factories, aircraft, and hospitals. Still, it is always the skill of people which transforms inanimate buildings and machines into productive devices. The Nation's efforts to clean up and preserve its water resources are no exception. In the last analysis, the success of this effort will also be determined by people.

This need for trained personnel in the clean water field has become particularly demanding in recent years. The construction rates of both municipal and industrial waste treatment plants have been accelerated. Treatment plants have grown larger and more complex and—as with aircraft and vessels—require more highly trained operating staffs. Better and more reliable treatment of wastes is necessary to provide the clean water being demanded by the public. But this is only the beginning.

The 1965 and 1966 amendments to the Federal Water Pollution Control Act are generating further increases in demands for trained personnel of all types. For example, the appropriation authority for financial assistance grants to communities for the construction of waste treatment facilities will increase sixfold by 1971 when it reaches a level of $1,250 million. The resulting program acceleration produces demands for personnel by consulting engineers, State agencies, and municipalities. Industry will also expand waste treatment facilities to meet the requirements of the water quality standards developed in accordance with the Water Quality Act of 1965. The entire clean water program would be delayed if significant manpower shortages were to develop or if the available manpower were not adequately trained for the jobs which must be done.

In recognition of this problem, the Congress has directed that a national study be made of trained manpower needs and training resources. The Clean Water Restoration Act of 1966, which became effective on November 3, 1966, provided that:

> The Secretary shall also make a complete investigation and study to determine (1) the need for additional trained State and local personnel to carry out programs assisted pursuant to this Act and other programs for the same purpose as this Act, and (2) means of using existing Federal training programs to train such personnel. He shall report the results of such investigation and study to the President and the Congress not later than July 1, 1967.

This report has been prepared in response to this congressional directive. The data on which this report is based were obtained from a variety of sources, including interviews with State agencies; prior manpower reports prepared by other agencies; discussions with Fed-

eral agencies conducting training programs; Bureau of the Census employment data; a recent report on State water pollution control manpower needs prepared by the Public Administration Service under a contract with the predecessor agency of the Federal Water Pollution Control Administration; and discussions with the Water Pollution Control Federation, a professional organization active in the waste treatment field.

MANPOWER AND TRAINING NEEDS IN WATER POLLUTION CONTROL

Part I. The Report in Brief

THE NATIONAL INVESTMENT

Within the last few years the Nation has committed itself to a greatly accelerated program to clean up and preserve its water resources. It is estimated that national expenditures for facilities to treat industrial and municipal wastes have amounted to over $1 billion in the past year and $9 billion in the past 14 years. This is only the beginning; even greater expenditures will be required in the years ahead. Maintenance and operation will also lead to continuing expenditures of large sums by municipalities and industry. The return, in the form of clean waters which the public receives from this investment, will depend largely on the availability of trained and qualified manpower.

THE PERSONNEL EQUATION

The next few years will witness a rapid increase in demands for personnel of all types in the clean water program. This need will extend from postgraduate trained scientists and engineers to the staff required for day-to-day operation of thousands of sewage treatment plants. No single geographic area will be exempt from this need.

Solution of the personnel equation requires knowledge of current and estimated employment, training needs, and those factors which influence initial recruitment and determine turnover rates. The following pertinent facts have been developed:

1. The current levels of employment have been determined and future needs estimated for qualified professional employees, technicians, and sewage treatment plant operators to staff State and local agencies. In every case, the estimates are believed to be highly conservative and are exclusive of replacement needs. It has been found that—

(*a*) About 3,600 scientists, engineers, and related professionally trained personnel are now employed by State and local agencies. By 1972, about 9,000 should be employed. Thus, a minimum of 5,400 additional trained professionals will be needed by State and local agencies within the next few years, an increase of 150 percent. Increasing complexity of pollution problems will undoubtedly require that many of these future employees have a higher degree of training and that more professional disciplines be represented than in present-day operations.

(*b*) About 2,600 technicians are now employed by State and local agencies for work in laboratories and in the conduct of field studies. It is estimated that about 6,500 will be needed by 1972. This represents an increase of 3,900 over a 5-year period; that is, of 150 percent.

(*c*) Approximately 20,000 persons are employed for the operation of municipal sewage treatment plants. An estimate of needs, based on the authorized increases in Federal finanical support to communities for construction, indicates 30,000 trained operators will be needed by 1972.

(*d*) An additional 50,000 persons are employed as operator assistants and in maintenance of sewerage systems.

2. The personnel needs of State and local agencies cannot be considered independent of the total personnel needs of other employers in the field. Consulting engineers, suppliers of chemicals and equipment for waste treatment plants, and Federal agencies also have substantial demands for trained personnel. These employers, essential to the national clean water efforts, compete directly with State and local agencies for manpower and for use of training resources. As such, they must be taken into account to obtain a balanced understanding of the trained manpower equation. For example:

(*a*) It is estimated that 12,000 plant operators and 6,000 professionals will be required in 1972 for the 6,000 industrial waste treatment plants. This compares with a 1967 estimated employment of 1,700 professionals and 3,500 plant operators. The manpower requirements for industry will probably increase 250 percent by 1972.

(*b*) It is expected that needs by consulting engineers' firms for engineers and other professionals will increase from today's 6,000 to 21,000 by 1972. Also, consulting engineers are likely to need 15,000 more technicians.

3. The number of personnel employed and needed tells only part of the story. There is convincing evidence that levels of training and degrees of skill are at least equal in importance. Personnel who are not adequately trained, or whose training is out of date, are unlikely to be able to carry out their job responsibilities at acceptable levels of competence or efficiency.

The levels of technical training for professional employees are generally satisfactory, although there is a continued need for educational updating to keep pace with new developments. However, the skill levels of many sewage treatment plant operators are unsatisfactory. In many instances, the responsibility for operating costly sewerage systems has been relegated to poorly trained and poorly paid personnel. The result is continued pollution of the Nation's water and an unsatisfactory rate of return on the public's clean water investment.

CURRENT USE OF TRAINING RESOURCES

A great many agencies of Federal, State, and local governments have programs dealing with university-level education, vocational training, and short-course training. In general, these efforts fall into two major classes: (1) support of higher education or vocational training and (2) conduct of specialized training, including short courses. A detailed review of all the professional discipline needs of the clean water program could not be undertaken in the time available for the study. The report, therefore, deals only with those training programs oriented directly to water pollution control:

1. The Federal Water Pollution Control Administration's training efforts are directly oriented to water pollution control personnel. They include:

(*a*) Graduate training grants and research fellowships to universities and individuals for the training of engineers and scientists.

(*b*) Research grants awarded to universities for conduct of specific research projects. These awards also have the long-term effect of increasing the supply of highly trained scientists and engineers through indirect support for graduate students. In 1966, a total of 269 grants supported an estimated 431 graduate students.

(*c*) Technical training and facilities grants to technical-vocational schools and junior colleges to train technicians and sewage treatment plant operators. (This program is scheduled for initiation in fiscal year 1968.)

(*d*) Encourage States to place increased emphasis on training programs. This action reflects the Clean Water Restoration Act of 1966, which emphasizes the importance of including training in State programs receiving support from program grants.

(*e*) Short-course training for all levels of employees. These courses are generally used for the updating and upgrading of skills and professional knowledge.

2. The Office of Water Resources Research of the U.S. Department of the Interior has provided grant support for establishment of water resources centers in each State. These centers are making a substantial contribution to the training of professionals in all aspects of water resources, including pollution control. In the 1965–66 school year, 13,650 water-oriented students were enrolled in participating institutions.

3. Most State water pollution control agencies now offer some short-course training for sewage treatment plant operators. The Water Pollution Control Federation reports that these courses, offered by 43 States, reach about 8,000 operators each year. The generally unsatisfactory levels of operations and maintenance of waste treatment plants suggest that these efforts fall far short of meeting qualitative requirements. This anomaly focuses attention on the need for continuing review of the effectiveness of such courses in terms of improved operation of waste treatment plants.

4. The Missouri Water & Sewerage Technical School at Neosho, Mo., has achieved a nationwide reputation for the quality of its training programs and might serve as a model facility for other regions. This institution receives direct or indirect financial support from State and local agencies, consulting engineers, the suppliers of chemicals and equipment, Federal Water Pollution Control Administration, and U.S. Department of Labor.

5. Comparison of present training activities with personnel needs leads to the conclusion that present efforts are inadequate, particularly in the training of operators for waste treatment plants. Unless corrective action is taken, this imbalance will continue to increase due to expanding program demands for trained personnel by all classes of employers involved in the clean water program. However, corrective action must be concerned with both the quality and quantity of the training efforts and must seek continually to apply new training methods and concepts.

83-681 O—67——2

RECRUITMENT, RETENTION, AND UTILIZATION

In the last analysis, the availability of trained manpower at the point of need will—despite training programs—be determined by such factors as salary levels, job prestige, merit system coverage, opportunities for advancement, and public acceptability and community status of jobs in the clean water field. Any approach to the problems of manpower which ignores these very practical considerations would be incomplete. Numerous opportunities also exist for improving employee productivity through job analysis, increased automation, and redesign of facilities. Examples of problems and opportunities include:

1. Conditions of employment: There is convincing evidence that the current high vacancy rates in some State agencies are due to noncompetitive salaries rather than a shortage of qualified individuals. Poor salary structures and lack of merit system coverage are also major factors in recruitment and retention problems of sewage treatment plant operators. In addition, the very nature of many jobs connected with sewage treatment plant operation have a relatively low level of prestige and community acceptance.

2. Operator licensing: Experience has shown that mandatory licensing of treatment plant operators upgrades the positions and thereby minimizes problems of recruitment and retention. Operator licensing has the combined effect of upgrading skills—necessary for effective operations—and upgrading job classifications, necessary for the attainment of competitive salary levels.

3. Increased use of automation: Numerous opportunities exist throughout the water pollution control field for the application of automation techniques both to reduce total manpower needs and to reduce the skill levels required in specific situations. These opportunities—present in professional, technician, and treatment plant operator employment classes—include the use of computers for routine engineering calculations and preparation of repetitive detailed drawings. These opportunities also include the use of remote sensing devices for stream monitoring, laboratory analysis, and the operation of waste treatment plants.

4. Use of technicians and general reductions of skill requirements: The productivity of highly trained engineers and scientists can frequently be improved through increased use of professional administrators, technicians, and other supporting personnel. Job analysis techniques can also be used to identify the skill levels required to perform specific tasks. In many cases, redesign of equipment or tasks can also lower the skill levels required or reduce the total demand for manpower.

ACTION PROGRAMS

The Federal Water Pollution Control Administration (FWPCA) is encouraging action programs to assure that an acceptable supply-demand balance of trained manpower will be maintained. An effective action program will require—

1. Expansion of FWPCA training programs:
   (*a*) Initiation of training and facilities grants to technical-vocational schools and junior colleges for the training of technicians and sewage treatment plant operators and for providing

leadership and guidance in development of programs and curricula to be carried out by Federal and State training programs.

(*b*) Continued strengthening of university training programs through grants and fellowships.

(*c*) Encouragement and stimulation of State efforts in the training field through better use of State program grants.

(d) Expansion of the present short-course training program now offered through Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio, and extension to other regions as field laboratories are completed. The FWPCA training staff will also accelerate its work with State agencies and professional organizations in the development of training aids of various types, including basic courses.

2. Development of a cooperative Government-wide education and training program to make full use of existing federally assisted programs for developing professional and vocational skills. Federal agencies that are concerned with higher education, occupational and vocational education, and the prevention of poverty, administer 37 public laws for education and skill training, 21 for higher education and professional training, and 16 for nonprofessional training needs. Many of these programs have considerable potential for training technicians and operators for sewage treatment plants; however, this potential is largely unexploited at present, These programs include:

(*a*) The vocational education program, which in fiscal year 1968 will train and educate an estimated 6.5 million persons at a Federal cost of $275.1 million;

(*b*) The manpower development and training program, which in fiscal year 1968 will provide training for approximately 280,000 unemployed and underemployed personnel at a cost of $347 million;

(*c*) The community services and continuing education program, provided under the Higher Education Act; and

(*d*) The newly funded community development training program, provided under the Housing Act of 1964.

The FWPCA has initiated executive-level discussions with the agencies administering these programs to find ways of directing appropriate efforts into areas of interest to the Federal Water Pollution Control Administration.

3. Seeking to improve the stature and working conditions for operators of municipal waste treatment plants through extension of State and local merit systems and licensing of operators. The mandatory licensing of waste treatment plant operators has the general effect of upgrading job stature and salary and by upgrading the level of training, improving the operating effectiveness of the treatment plants. In the final analysis, it may be nceessary to seek an amendment to the Federal Water Pollution Control Act to require operator licensing for plants receiving Federal financial assistance.

4. Encouragement, stimulation, and assistance in the financing and conduct of technical and management research and development efforts aimed at improved employee productivity, reduction of skill levels, and reduction of total manpower needs. Areas which seem to offer the best opportunities include:

(*a*) Management studies, at all levels of employment from senior administration to operation of treatment plants, to determine how current personnel resources are used and, through job simplification, to obtain the maximum use of available manpower resources.

(*b*) Design of sewage treatment plants, treatment processes, and pumping stations to minimize maintenance needs, to make increased use of automation, and to reduce the skill levels required for adequate operation and maintenance.

(*c*) Encourage maximum use of technicians and supporting staff to achieve maximum use of the professionally trained staff.

5. Establishment of an Office of Manpower and Training. This Office will guide, coordinate, and schedule the various FWPCA programs concerned with manpower and training. In addition, this Office will be responsible for the establishment of objective goals for training programs, with the continuing application of systems to measure training effectiveness (as contrasted with the number of students) and for stimulation of technical and management research and development projects aimed at increasing employee productivity.

6. Current legislative proposals would, if adopted, have a significant impact on future FWPCA manpower efforts. The proposed Intergovernmental Manpower Act of 1967 (S. 1485 and H.R. 8233 and similar legislation), pending before the Congress would strengthen State and local government personnel systems and would greatly assist the development of needed personnel and job skills. The legislation provides for—

(*a*) Additional authority for Federal training and Federal assistance to State and local training programs.

(*b*) Cooperative Federal-State and Federal-local recruitment and examination activities.

(*c*) The interchange of employees between the Federal Government and the State and local governments.

(*d*) The extension of merit systems to State and local employees as a requirement of Federal assistance.

(*e*) Grants to State and local governments for government service scholarships.

If this legislation is enacted, the Federal Water Pollution Control Administration, together with the Civil Service Commission and other appropriate agencies, will develop procedures for utilizing the new authorities in addition to ongoing efforts to provide for State and local governments' education and training needs.

Part II. Manpower

PRESENT RESOURCES AND FUTURE REQUIREMENTS

This part presents an analysis of the needs for trained personnel in terms of skill levels (professional, technician, and sewage treatment plant operators) and employer classes (State and local governments, consulting engineers, and industry). Emphasis has been placed on the manpower resources and needs of the State and local agencies, but with the full recognition that the manpower needs of other groups such as Federal agencies, industry, and consulting engineers exert a demand upon the same resource pools. The following terms are used to describe skill levels:

Professional: A great many disciplines are included in the professional category such as chemical, mechanical and sanitary engineers, aquatic biologists, marine biologists, oceanographers, microbiologists, chemists, economists, and public administrators. This range of disciplines is continually widening, reflecting the growing complexity of water pollution control problems.

Technicians: Technicians perform a wide array of tasks including laboratory assistance, repair of equipment, computer programing, data analysis, and collection and preparation of samples for laboratory examination. Educational needs include technical-vocational school or junior college. In a few instances, college graduates are utilized.

Sewage treatment plant operators: These individuals are responsible for the day-to-day operation of the sewage treatment plants and mechanical equipment, such as pumping stations and recording gages, associated with sewer systems. In small communities, the operator may have sole responsibility for the operation of the entire system, whereas in larger cities, he is responsible to a professional employee. The primary level of education is generally high school, technical or vocational school or junior college depending on the size and complexity of the plant. The term does not include laborers or tradesmen, such as electricians or plumbers, who have a secondary role in determining the operating effectiveness of the system.

This part of the report deals with numbers of persons now employed and the estimated needs for the 5-year planning period to and including fiscal year 1972. A discussion of skills and training needs is presented in the following part. The numbers of personnel required for normal replacements due to death, retirement, and transfer to employment outside of the clean water field are not included because (1) reliable data on turnover rates were not available and (2) evidence indicates that a substantial part of employees who resign seek reemployment in the same specialized field; that is, a consulting engineer or equipment supply firm may recruit from State or local agencies. Additional information on sources of data is included in appendix A.

PROFESSIONAL EMPLOYEES

Scientists, public administrators, and engineers, constituting the professional employment category, are employed in substantial numbers by Federal agencies, State agencies, municipalities and special districts, consulting engineers, and suppliers of chemicals and equipment used in waste treatment and universities. Professional employees are also frequently engaged in overseeing the operation of waste treatment plants for large cities, sanitary districts, and industry.

Data on current employment and projected needs were obtained through interviews with administrators of the State water pollution control agencies and examination of prior manpower reports. A prior report on manpower needs made by the Public Administration Service for the predecessor agency of the Federal Water Pollution Control Administration was particularly helpful in estimating resource needs for the State water pollution control personnel. Data on probable personnel needs for consulting engineers' firms were obtained through an industrywide study conducted by a well-known consulting engineers' firm, Black & Veatch, Kansas City, Mo., for the Federal Water Pollution Control Administration. Estimated needs for professional staff for the industrial waste treatment needs were computed on the basis of best estimates of construction needs. (A detailed analysis of personnel needs in the industrial waste treatment field was not undertaken because of lack of precise information on current industrial waste treatment needs. The FWPCA is currently undertaking a nationwide study of such a need in accordance with section 16 of the Federal Water Pollution Control Act, as amended.) Estimates were not developed for professional manpower requirements for the many firms supplying chemicals and equipment for waste treatment.

The projections for increased manpower requirements at all levels of employment reflect the accelerated national programs called for by the Federal Water Pollution Control Act, as amended. This acceleration will be reflected in all elements of clean water programs, including the establishment and administration of water quality standards' programs by all States: increased rates of construction for municipal and industrial waste water treatment plants reflecting increased authorizations for Federal financial assistance for construction and a growing number of federally instituted pollution abatement enforcement actions; and adoption of the river basin concepts of water pollution control. Total employment and needs are shown in table I.

State agencies

Estimates for levels of current employment and needs are based upon direct FWPCA interviews with the administrators of the water pollution control agencies in each of the 50 States and a 1964 study of needs made by the Public Administration Service.

The data generated by interviews with the approximately 250 State administrators and senior engineers disclosed that, for 1967, the States had a total of 1,728 positions, of which 368 were vacant; that is, a vacancy rate of 21 percent.

The FWPCA survey of State personnel needs also determined the current needs within respective disciplines:

Professional disciplines	Number of positions	Number employed	Number of vacancies	Percent vacancies
Engineers	936	700	236	25
Administrators	157	140	17	11
Chemists	213	175	38	18
Microbiologists	70	55	15	21
Aquatic biologists	129	100	29	22
Others	223	190	33	15

The State administrators estimate that their programs will need 3,422 professionals by 1972. These estimates are made by experienced administrators aware of the current requirements of the Federal Water Pollution Control Act, as amended, and reflect firsthand knowledge of workloads. However, the estimates by the State administrators may have been tempered by their own budgetary experience which might result in a tendency to understate needs. A comparison of the State administrators' estimates with those of the Public Administration Service (PAS) study made in 1964 and those of the Committee on Environmental Health Programs, 1962, suggest that they are, in fact, conservative.

The information obtained from the State administrators does not permit a detailed analysis of the causes for the reported vacancy rates nor of the length of time the positions have been vacant. However, the salary scales for some State agencies are not competitive and are probably a determining factor in producing vacancies. The salary problem was also noted in the PAS study conducted in 1964.

A professional/technician ratio of about 6:0 (six professionals for each technician) was reported by the State administrators. This ratio seems high and suggests an opportunity for meeting future needs through more efficient use of personnel; that is, a greater percentage of technicians.

The Public Administration Service study of State agency needs was based on an examination of general workloads and the resources needed to meet these workload requirements at an acceptable level. These estimates were then compared with actual State employment practices and needs in 13 States, considered to be representative of the range of problems encountered in the United States. The study indicated a professional manpower need in 1964 of 2,760 positions. This estimate was made prior to the 1965 and 1966 amendments to the Federal Water Pollution Control Act and would require an upward revision to reflect additional workloads. No estimates were made of needs for specific disciplines or levels of training required. The professional/technician ratio varied from 5:5 to 1:0 in the 13 States which were studied.

The Committee on Environmental Health Problems (Public Health Service, U.S. Department of Health, Education, and Welfare) conducted a study of manpower needs in 1962. The study concluded that there would be a need for 4,600 professional employees for water supply and pollution control programs in the State agencies by 1970; the other studies deal only with pollution control. This value is consistent with the estimates of the Public Administration Service and tends to suggest that the estimates made by the State administrators are conservative.

The total demand for professional manpower by the States is based on estimates of the State administrators. The demand exclusive of replacements consists of—

Immediate needs to fill vacant positions	368
Staff for expanded programs	1,686
Total number of additional personnel required by 1972	2,054

Local agencies (municipalities and special districts)

Many municipalities, counties, and sanitary districts are directly involved in water pollution control programs. These personnel are engaged in long-range planning; design and supervision of construction; sewer maintenance and inspection; and supervision of operations of large waste treatment plants. The trend toward larger, centralized sewerage systems will affect future manpower requirements in this important sector of employment.

Direct employment data on professionals employed by municipalities in water pollution control programs were not available. An estimate was therefore made through analysis of the 1966 Directory of the Water Pollution Control Federation. Approximately 1,500 professional employees were identified by this process. This value was increased by a factor of 50 percent in recognition of the fact that many professionals, for example, bacteriologists, would not belong to this particular professional organization. On this basis, it is estimated that 2,250 persons in various professional capacities are employed by local governments for water pollution control activities.

The existence of vacancies and requirements for expansion of this professional group could not be studied in as much detail as for the State agencies. However, it is apparent that future requirements for personnel will be affected by construction of additional facilities for collection and treatment of waste water and by implementation of water quality standards. Employment opportunity advertisements carried in the professional journals indicate a well-developed current demand for staff. In the absence of specific data, it is assumed that the demand pattern will follow that of the States and that an increase of about 150 percent will take place in the 5-year period. There would then be a requirement by 1972 for approximately 3,250 new professionals trained in water pollution control work, or a total of 5,500 professionals. This is equivalent to an annual increase of 650 professionally trained employees per year.

Industrial waste treatment

Substantial numbers of professional personnel are employed by industry to supervise the operation and maintenance of waste treatment facilities and for making laboratory and field studies of pollution problems. Current employment estimates were developed by the FWPCA on the basis of the number and size of existing waste treatment plants. The quantitative reliability of these estimates could not be ascertained by sampling procedures in the time available for the project. Projections of future manpower needs in the absence of definitive information on industrial waste treatment plant needs are also open to question. The Federal Water Pollution Control Administration is now making a nationwide study of needs for industrial waste treatment in accordance with the requirements of section 16 of the Federal Water Pollution Control Act, as amended. This report,

to be submitted to the Congress by January 10, 1968, will provide the base for a reliable evaluation of manpower needs in this important area.

On the basis of best available information, it is estimated that 1,700 professionals are currently employed in industrial waste treatment facilities. Approximately one-half of these employees are believed to be engineers and the other half, chemists. It is estimated that approximately 6,000 professionals will be needed by 1972, an increase of 4,300 over the present estimated employment.

Equipment and chemical suppliers

The 1967 Yearbook of the Water Pollution Control Federation lists 127 firms that hold associate membership in the federation. Many of these firms have nationwide coverage through networks of regional offices. They undoubtedly employ substantial numbers of professional employees for servicing the waste treatment industries. However, these firms also supply a variety of products and services to other industries and it was not practical, in the time available for the study, to undertake a detailed examination of how professional time is allocated to these various activities. The absence of even rough estimates of personnel needs for this field of employment adds another element of conservatism to the total projections.

Consulting engineers

Two techniques were used for developing estimates on professional employment and needs in the consulting engineering field: (1) A review of the yearbook of the Water Pollution Control Federation which lists consulting engineers and their employment of professionals in the water pollution control field, and (2) a study conducted by Black & Veatch, consulting engineers, for the Federal Water Pollution Control Administration.

The review of the yearbook indicated that 186 consulting firms are active in the field of water pollution control. These same firms reported 5,100 professionals engaged in water pollution control work on their staffs. This value has been increased to 6,000 on the assumption that not all consulting firms' employees are reported in the yearbook. This estimate is consistent in general magnitude with the Black & Veatch estimate which indicates that 7,650 professional personnel will be required by 1968.

Consulting engineers employ professionals in the same disciplines as State and local agencies. However, the demand for civil and construction engineers is greater, both in terms of numbers and as a percentage of total employment. This relationship reflects the role of the consulting engineer in the actual design of waste treatment plants and in overseeing construction.

TECHNICIANS

Technicians are employed in a variety of tasks, including the collection and preparation of water and biological samples for laboratory examination; performance of routine laboratory examinations and assistance to professionals with more complex examinations; drafting; data processing, including computer programing; and repair and maintenance of various types of equipment. As such, they are employed by all classes of employers interested in the clean water program.

83-681 O—67——3

State agencies

State water pollution control agencies reported to the FWPCA that a total of 317 technicians are employed. They also estimated that this need would increase to 980 by 1972. These values indicate that the professional/technician ratio will decline from 6:0 to 5:0; current State plans provide for only a slight increase in use of technicians to support professional staff. No statistics are available on disciplines needed in this general class of employment.

Employment needs for technicians were also considered in the Public Administration Service study. The study concluded that a total of 1,240 technicians would be needed by 1972. This estimate was based on a professional/technician ratio of 2.2—less than one-half of that reported by the State administrators for current employment. If the current State ratio of 6:0 were applied to the PAS personnel estimate, the demand for technicians would amount to 570, a value close to that estimated by the States. There is, therefore, reasonable agreement between the two studies, although the States envision the use of fewer technicians than recommended by PAS.

Local agencies (municipalities and special districts)

Estimates of employment were developed through reference to the 1966 yearbook, Water Pollution Control Federation. The data indicate that 2,250 technicians are now employed by local agencies.

The ratio of professionals to technicians is apparently substantially lower in local governments than in the State agencies; that us, about 1:0. This difference probably reflects the somewhat different program responsibilities of the State and local governmental agencies. It was estimated that the need would increase to 5,500 technicians by 1972. This estimate includes the assumption that the rate of increase will be proportional to the rate of the State agencies and that there will be no substantial change in the professional/technician employment ratio.

Industrial waste treatment

Data were not obtained on the number of technicians employed in industrial waste treatment. However, it seemed reasonable to assume that the professional technician ratio for industry would approximate that of the local government (1:1), rather than that of the State governments (about 6:1); they have a higher emphasis on administrative activities. On this basis, it has been predicted that the current level of employment is 1,700 technicians and that this employment will increase to 6,000 by 1972. These estimates can be better evaluated when the current national survey of industrial waste treatment needs is concluded by the FWPCA.

Equipment and chemical suppliers

Data on employment of technicians by this element of industry were not available.

Consulting engineers

Technicians are used in large numbers by consulting engineers as draftsmen, in data analysis, and in the conduct of water quality studies. The ratio of professionals to technicians varies with the size of the firm, but in general, it is approximately 1:0; that is, one professional employee for each technician. On this basis, it is estimated

that about 6,000 technicians are now employed. It is estimated that this demand will reach 21,000 in fiscal year 1972, reflecting a greatly accelerated program for design and construction of municipal and industrial waste treatment plants. No change in the professional/technician ratio is forecast.

SEWAGE TREATMENT PLANT OPERATORS

Estimates of the current employment levels of sewage treatment plant operators are based on (1) an FWPCA analysis of the numbers, sizes, and types of sewage treatment plants and (2) an analysis of operator needs prepared by the Water Pollution Control Federation on the basis of projections by the Conference of State Sanitary Engineers. The estimates include only those employees who, by their action and knowledge, determine the operational effectiveness and efficiency of a waste treatment system. The estimates do not include laborers, tradesmen, such as electricians or pipefitters, supervisory professional staff, or laboratory technicians. No direct information was available on total numbers of budgeted positions, vacancies, or turnover rates. The estimates also exclude the substantial needs for operators of the many Federal facilities.

State agencies

State water pollution control agencies are not, by themselves, significant employers of sewage treatment plant operators, although this situation may change in the foreseeable future. For example, the Commonwealth of Puerto Rico has developed a system whereby all waste treatment plants are operated by an instrumentality of the Commonwealth government. Such a realinement of responsibilities should not materially affect the total numbers employed, although it would affect both employment classification (State versus local) and the ratio of operators to total employees.

Sewage treatment plant operators employed to operate State-owned facilities are included under the "Local agencies." Specific data on the number of such employees were not immediately available.

Local agencies

The FWPCA estimate prepared on the basis of numbers, sizes, and types of waste treatment plants indicates 16,500 operators are now employed. In comparison, the Water Pollution Control Federation estimates that 19,400 operators are now employed. These values compare with Bureau of the Census estimates that 70,000 persons are now employed by municipalities in the operation and maintenance of sewers, pumping stations, and treatment plants. The Bureau of the Census value includes laborers and general maintenance staff.

It is difficult to make a meaningful appraisal of the accuracy of the first two estimates in the absence of direct sampling data. However, the fact that both are of the same general magnitude and are compatible with the total employment statistics of the Bureau of the Census suggests they are reliable. The relatively low level of current employment is due probably to the large number of small, quite simple treatment plants now in use in the United States. In many cases, the "operator" of such a plant has other municipal duties and devotes only a portion of his time to the treatment plant. In contrast, larger municipalities and sanitary districts have complex treatment plants which require essentially around-the-clock supervision by trained operators.

It is the general impression of both State and Federal experts in water pollution control that the current supply of trained operators is inadequate; however, this impression can be neither validated nor invalidated by available employment data.

The predicted needs for trained operators for 1972 will be determined to a large extent by the rate at which waste treatment plants are completed. The demands for operating personnel lag well behind construction appropriations. For example, several years are usually required to design and construct waste treatment plants. Thus, the major expansion in construction which is forecast for 1971 and 1972 will not produce a concurrent demand for operators. (In contrast, the consulting engineer who must prepare the plans and oversee the construction has an immediate need for personnel.)

Changes in technology certainly influence manpower requirements, but the net effect is not readily calculated. Large-size plants offer obvious economies of scale; however, demands for a higher degree of reliability and more complete treatment may balance out this gain. Automation can also be expected to reduce personnel needs. This reduction would probably affect overall employment to a greater extent than the need for trained operators; that is, fewer people but higher skills.

It is estimated that employment of sewage treatment plant operators by local agencies will increase to approximately 30,000 by 1972. This estimate is based on the premise that, by 1972, 80 percent of the communities now discharging sewage without treatment will have constructed secondary treatment plants; that 50 percent of today's primary treatment plants will have been upgraded to secondary treatment; and that additions to present plants will be sufficient to service two-thirds of the estimated population increase. It is further assumed that the improvements in automation and scale economies for large plants will balance the demands for increased reliability and, in some instances, demands for tertiary treatment.

Industrial waste treatment

Industries, like municipalities, are faced with growing problems in the treatment of wastes. In many cases, industry will elect to connect their plants to municipal systems and to turn the job of waste treatment over to a municipality. However, there are many situations in which this is not practical nor economically feasible. It is estimated that there are presently about 6,000 major industrial plants in the United States which generate significant quantities of liquid waste. About 25 percent of these plants now discharge wastes into municipal sewers; 25 percent provide adequate treatment through their own facilities; and 50 percent discharge wastes without adequate treatment.

A reasonable prediction of industrial growth indicates that approximately 2,800 industrial waste treatment plants will be constructed and staffed during the next 5 years. It is estimated that this construction will require an additional 8,500 operators by 1972. This estimate is based on plant operator requirements similar to those of municipal treatment plants.

Total manpower needs

Estimated manpower needs for all classes of employees are summarized on table I.

TABLE I.—ESTIMATES OF MANPOWER REQUIREMENTS

Employers	Fiscal year 1967			Fiscal year 1972								
				Professionals			Technicians			Sewage treatment plant operators		
	Professionals	Technicians	Sewage treatment plant operators	Estimate	Increase	Percent increase	Estimate	Increase	Percent increase	Estimate	Increase	Percent increase
State agencies	1,368	317	.....	3,422	2,054	150	980	633	209	.....	.....	.....
Local agencies	2,250	2,250	20,000	5,550	3,250	144	5,500	3,250	144	30,000	10,000	50
Subtotal [1]	3,600	2,600	20,000	9,000	5,400	150	6,500	3,900	150	30,000	10,000	50
Industrial waste treatment	1,700	1,700	3,500	6,000	4,300	253	6,000	4,300	253	12,000	8,500	243
Consulting engineers [2]	6,000	6,000	.....	21,000	15,000	250	21,000	15,000	250	.....	.....	.....
Total [1]	11,300	10,300	23,500	36,000	24,700	219	33,500	23,200	225	42,000	18,500	80

[1] Numbers are rounded.
[2] Estimated by Black & Veatch, consulting engineers.

Part III. Educational and Training Needs

The educational and short-term training needs of the clean water program are extremely varied. They extend from self-help, on-the-job training for sewage treatment plant operators, to post-doctoral education for scientists and engineers in research and administration. Similarly, the need for training extends to all classes of employers—State and local agencies, consulting engineers, Federal agencies, and suppliers of chemicals and equipment. Training efforts are also concerned with the upgrading and updating of skills of currently employed personnel; with the provision of labor pools from which to recruit new employees; and with the provision of specialized skills for employees recruited from other professional or skill areas. For example, short-course training can provide a civil engineer with basic skills in water pollution control.

The levels of training and experience of employees is a major factor in determining both the success and cost of the Nation's clean water effort. Administrative and research programs must be imaginative and provide effective tools with which to meet constantly changing problems. Treatment plants must be designed to modern standards of effectiveness and reliability and must utilize the best possible techniques. Laboratory examinations must be reliable, accurate, and as inexpensive as possible. Treatment plants and sewer systems must be operated and maintained at their designed operating efficiency. The degree to which these goals are attained will be determined to a considerable extent by the degree of training of the many types of employees.

PROFESSIONAL EMPLOYEES

A review of projected needs for trained professional personnel indicates the following needs by 1972: State agencies, 2,000 professionals; local agencies, 3,250 professionals.

Agencies will attempt to fill their needs through (1) recruitment of new graduates, (2) recruitment from allied fields, and (3) recruitment from other agencies. State and local agencies must compete with other potential employers such as consulting engineers and supply firms. The needs of these organizations are predicted to exceed those of the State and local agencies. The demand for professional personnel consists of two elements, the total supply of professionals and those with specialized training in water pollution control.

The general supply of engineers available to all employers indicates shortages and a competitive employment situation. The Engineering Manpower Commission of the Engineer's Joint Council, for example, indicated that the total demand for engineers for the 1965–76 period should exceed supply by 70 percent. This would create a major imbalance in the engineer supply—demand balance, and would require that State and local personnel systems be competitive with industry and Federal agencies.

The following discussion deals only with the formal education in the specific water pollution control field. This recognizes that specialized training is needed in many elements of the water pollution control field and that disciplines other than the specialists are also used in substantial numbers; that is, civil engineers for construction programs

Formal training

The clean water programs draw upon a wide range of professional talents, includings anitarye ngineering, microbiology, aquatic biology, chemistry, chemical engineering, and marine biology. In many cases, extensive training in water pollution control subjects may be needed. However, there are many instances in which the required skills are more directly allied with another discipline; as, for example, chemistry, or microbiology. The data on current State employment indicate that about one-half of these professional employees are in the various engineering fields and the other half are in other professional disciplines. This broad spectrum of educational requirements makes it difficult to make a definitive projection on specific training needs.

This is not an unusual situation. For example, when the space program started, there were very few "space scientists." However, many professionals were attracted by the challenge of the project, and a major space program was undertaken. It appears that the professional supply for the water pollution control programs is in a similar situation. These programs are challenging and now have widespread public support. Positions apparently can and are being filled where salary levels are competitive and where adequate job opportunities exist. For example, the 1966 Annual Report of the Office of Water Resources Research notes that the universities participating in the OWRR program obtained 249 new staff and 56 staff replacements. The Federal Water Pollution Control Administration has also been generally successful in its recruitment efforts, and several States indicate relatively low recruitment needs.

Information on levels of training required for future employees was not provided by the State administrators. However, the earlier study made by the Committee on environmental Health Problems, Public Health Service, Department of Health, Education, and Welfare, indicated that approximately 70 percent of the staff should be expected to have advanced degrees. This conclusion can be compared with the results of a Stanford Research Institute study of a major California aerospace company. This study found that only 13 percent of the scientists and engineers had advanced degrees as compared with 52 percent with bachelor's degrees.[1] The projection is also at variance with industry's experience which exerts a maximum demand for high educational levels in the early developmental stages of a program, with diminishing demand as a project enters production phases.

The technical problems of water pollution control are becoming more complex, and there is a clear qualitative trend toward requirements for higher levels of formal education, both in terms of degree level and in scope of training. Congress has recognized this need, as it relates to water resources, through enactment of the Water

[1] "Applying Technology to Unmet Needs," appendix 5, the Report of the Commission on Technology and the American Economy, U.S. Government Printing Office, February 1966.

Resources Research Act of 1964 (Public Law 88–379) and its amendments in 1966 (Public Law 89–404). In 1966, institutions participating in this program graduated 3,168 students with bachelor's degrees; 1,206 with master's degrees; and 353 with doctoral degrees. The enrollment in participating institutions during the 1966–67 school year was 13,650 as compared with 8,958 during the 1964–65 school year. It thus appears that a substantial cadre of personnel trained in water resources is developing and that enrollment is increasing.

There is no evidence at the present time that the steps, taken by the Congress to assure a sufficient number of specially trained professionals in the water resources field, are inadequate. Similarly there is no evidence that significant personnel shortages are apt to develop in State or local agencies; *providing salary levels and employment opportunities are competitive.*

Short-course training

Short-course training offers the best potential for updating of professional skills and for development of specialized skills in personnel recruited from allied fields. The complex nature of the water pollution control field requires that such courses cover a wide range of subjects from basic water-pollution control skills to analytical chemistry procedures. The rapid rate of technical change in the water pollution control field is such that there is probably a sound justification for each professional employee attending at least 1 week of short-course training per year. State and local agencies report a total professional employment of 3,618 persons; however, the short-term training courses offered by the FWPCA for fiscal year 1968 are projected to reach only about 1,000 students. This latter value includes employees of Federal agencies and industries.

TECHNICIANS

Formal training

Technicians are generally recruited from technical-vocational schools and junior colleges. Types of training which are required include a great variety of subjects from data processing to operation of sophisticated analytical chemical equipment. Data on specific vacancies and training needs for this class of employees are not now available.

In general, training programs which have been offered by schools have not been directly associated with the water pollution control programs, although, they have offered a wide variety of courses useful to technicians employed in this field. Development of additional well-identified courses directly related to water pollution control should have the effect of encouraging their graduates to seek employment in the clean water field.

Short-course training

The need for specialized skill development of technicians covers an exceedingly wide range of subjects from drafting and data analysis to that of an assistant in chemical and microbiological laboratories. Substantial opportunities also exist for upgrading skill levels of technicians and thereby reducing the professional-technician ratios, to obtain greater productivity from the present supply of professional personnel.

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SEWAGE TREATMENT PLANT OPERATORS

Formal training

No data are available on the labor pools from which present operators were recruited; however, it is believed that many entered the field in a maintenance or helper capacity and, through experience and on-the-job training, were promoted to levels of more responsibility.

The construction of treatment plants which are larger and more complex suggests that relatively higher levels of education are desirable to assure an adequate return from this large public investment. The recruit of graduates of technical-vocational schools and/or junior colleges as future operators would help to provide the basic educational background for this type of employment. However, few such schools now offer training which would lead to such employment.

Short-course training

The need for skill enhancement appears to be best defined in the case of sewage treatment plant operators. Needs exist both for training of personnel entering this employment area and for training of operators presently employed.

Needs for skill enhancement of sewage treatment plant operators cover a wide technical area including such subjects as relatively basic courses in waste treatment, business administration, chemistry, and bacteriology, and day-to-day operation and maintenance of equipment. The success of such training should be measured in terms of results (effective operations of treatment plants) rather than efforts devoted to training. Technical problems faced by operators of industrial waste treatment plants may require special training; however, this may well be considered to be a responsibility of management rather than government.

A recent statement attributed to the director of the Bureau of Sanitary Engineering, Arkansas State Health Department, exemplifies the need for adequate training of sewage treatment plant operators.

> Some Arkansas cities spend large sums of money building modern sewage treatment plants, then turn them over to untrained staffs to operate, a State health department official said Monday.
>
> "I can't think of a better example of false economy" declared Glen T. Kellogg, director of the bureau of sanitary engineering. "What sense is there in spending $100 000 to $200,000 on a plant and giving a man $200 a month to run it?"
>
> "The result is that the poorly run treatment plant winds up dumping partly treated waste into public streams adding to pollution control problems" Kellogg said.
>
> Kellogg said "at the end of 1966 there were 199 sewerage systems in the State and 176 gave complete sewage treatment operation 24 hours a day. The larger plants are operated by sanitary engineers."
>
> "Jobs in other plants often are filled on the basis of political patronage or low wages" Kellogg said. There is no State law licensing these operators nor does the board of health have any requirements for sewage plant operators.
>
> As a result Kellogg has tried to plug the gap by encouraging cities to send treatment plant employees to short-course schools he conducted. Last year 56 operators passed tests on waste treatment in these courses.
>
> Kellogg said that "this brought to 115 the number of operators with practical basic knowledge in waste treatment." Since the program is voluntary not all cities take advantage of the offer.
>
> Kellogg preaches the passage of a mandatory sewage treatment operators licensing law. He said that "if the public is to protect itself and its investment in sewage treatment plants and if the pollution control laws are meaningful such a law must be passed."
>
> The State pollution control commission supports Kellogg's efforts.[3]

[3] Arkansas Gazette, Mar. 28, 1967.

It would be desirable to provide some training for each of the currently employed sewage treatment plant operators during fiscal year 1968. The resources currently available to the States and the FWPCA would permit a substantive qualitative attainment of the goal. However, smaller communities may be reluctant to permit operators to attend because of travel costs and costs for relief operators.

Part IV. Training Programs and Opportunities

The Congress has, over the years, enacted a great variety of legislation dealing with the various aspects of higher education, vocational training, and short-term training. An examination of the various programs and authorities, in terms of meeting needs for trained personnel by State and local agencies for water pollution control programs, indicates that a need exists for coordination, redirection, and implementation rather than a need for a greater, or new, authority. However, the ultimate success of State and local agencies in the recruitment and retention of personnel will be influenced greatly by salary scales and job opportunities.

PROFESSIONAL EMPLOYEES

Formal training

The following discussion deals only with the formal training of water pollution control specialists and does not consider the total problem of availability of professional manpower. It is generally accepted that personnel demands will exceed the supply for the next several years and that competitive hiring conditions will exist. This situation will demand that water pollution control managers at all levels structure programs to make maximum use of the available professional staff.

The Federal Water Pollution Control Administration and the Office of Water Resources Research have programs that have direct effects on the supply of personnel trained in water pollution control and water resource fields.

The Federal Water Pollution Control Administration provides graduate training grants, technical training grants, and research fellowship grants for the training of postbaccalaureate degree students at colleges and universities. Graduate training grants are awarded to educational institutions to establish or expand advanced training in water pollution control. Under this program, institutions are encouraged to develop specialized and multidisciplinary training of scientists, engineers, and administrators in water pollution control. These grants may be used for expansion and improvement of facilities, equipment, and stipends for graduate students participating in the training program. Research fellowships are awarded to outstanding individuals for the support of graduate and postgraduate training. They are intended to assist in meeting the critical need for professional manpower having specialized training in a variety of disciplines. The Federal Water Pollution Control Administration's training grants program has been directed exclusively to graduate training.

The following numbers of students have been supported under these programs:

Fiscal year	Number of students completing training		
	Master	Doctoral	Total
1963	20	2	22
1964	52	7	59
1965	48	7	55
1966	64	28	[1] 92

[1] Data indicate that 32 of these graduates found employment with government, 26 with industry (including consulting engineers' firms), and 24 with educational institutions. 10 of the graduates continued their educations.

Research grants are awarded primarily to support research projects in water pollution control. However, the project contributes to the development of competent professional personnel and graduate students engaged in the project. Such training expands the manpower resources needed in the water pollution control field. The scientific disciplines involved include engineering, biological sciences, physical sciences, and social sciences. The staff and students receiving training in research grants program bring new and imaginative ideas to bear upon problems in this field. In fiscal year 1966, the 269 research grants supported 431 graduate students.

Funds requested in the President's budget for fiscal year 1968 will permit the support of about 500 students under the graduate training grants program and 85 under research fellowships.

The program of research and training administered by the Office of Water Resources Research (OWRR), U.S. Department of the Interior, has also had a significant impact on the training of professional personnel in the water resources field, including specialists for water pollution control. Fiscal 1966 was the first full year in which the 51 approved Water Resources Research Institutes operated with funds provided under the Public Law 88–379 program. The 1966 annual report of OWRR indicates that support was provided to more than 1,100 students representing 47 different scientific and engineering disciplines in 1966, double the number receiving support in 1965. The program has also had a significant impact on the provision of training facilities and in the development of necessary staff. During the 1965–66 school year, 13,650 water-oriented students were enrolled in these institutions; 3,762 as juniors; 4,430 as seniors; 3,513 as candidates for the master's degree; 1,899 as doctoral degree candidates; and 46 as postdoctoral students. This compares with a total of 8,958 reported for the previous year (1964–65).

The OWRR annual report for 1966 indicates that 3,168 students were graduated during the year with bachelor's degrees, 1,206 with master's degrees, and 353 with doctoral degrees. Employment data on the June 1966, graduates are incomplete. However, data on 1,585 graduating seniors (about one-half of the class) indicate that 648 obtained water-related positions (209 with Federal agencies, 154 with State agencies, 34 with colleges and unverisities, and 251 with other organizations such as private industry and municipalities). A total of 583 returned to school and 354 went into the military service.

Other agencies of the Federal Government including the Department of Health, Education, and Welfare, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the National Science Foundation support a variety of educational programs directed toward higher education. These efforts have a

collective positive impact on the total professional labor pool. However, it is impractical, except through sampling techniques, to determine the impact of these programs on the total supply of trained manpower for water pollution control. (Specific educational authorities are tabulated in appendix B.)

The accelerating programs of the Federal Water Pollution Control Administration and the Office of the Water Resources Research should assure that well-trained personnel are available to provide leadership for water pollution control programs. The ability of State and local agencies to attract and retain new graduates will, however, depend on their competitive position during a period in which the total demand for professional personnel is expected to be quite high.

The overall supply of professional personnel will, however, be generally inadequate to meet the projected demands of program managers. This deficit can be met only through better use of available trained personnel because of the long time required for professional training. Any program to stimulate professional training requires 4 or 5 years to produce significant results.

Short-course training

Short-course training fills an important role through (1) provision of specialized and basic skills for professionals recruited into water pollution control from other fields and (2) the continued updating of professional skills for experienced personnel.

The Federal Water Pollution Control Administration also offers a series of direct training courses. These are specialized technical courses for both professionals and subprofessionals in the field of water pollution control. This training has been based at the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, with some courses being offered at other locations. The construction of the FWPCA regional laboratories permits decentralization and expansion of this effort into a variety of geographic locations. Training courses are offered at Cincinnati, Ohio; Ada, Okla.; Corvallis, Oreg.; Athens, Ga.; College, Alaska; Denver, Colo.; and Metuchen, N.J. (A schedule of courses is listed in appendix C.)

This program has achieved an international reputation and students from all over the world have participated in the courses.

The regional training centers will expand their capacity to assist in the development of courses and training guides, and they will present specialized or general courses for subprofessional employees of State and local government and industries. These centers assist in providing teaching personnel for regional, State, or local training courses. The regional training centers will also begin to provide training in advanced waste treatment for plant operators.

Fiscal year 1968 plans of the FWPCA provide for the presentation of over 50 training courses which will serve an estimated 1,150 students, mostly professionals.

Many other Federal agencies also have training programs or training material of direct benefit to many technical and professional workers in the clean water effort. These resource areas have not been cataloged for the purpose of this report because of the exceedingly wide range of technical subjects which were covered. They include, for example, the Graduate School of the U.S. Department of Agriculture, which offers training in a variety of skills from remedial high school level courses to analytical chemistry. And, the Public Health

Service offers a wide variety of technical and professional courses through the National Institutes of Health and the National Center for Communicable Diseases.

There is an apparent gap between the number of students who would benefit from training and the opportunities for attendance. It is estimated that most professional employees would benefit materially from participation in at least one training course per year and that new employees would benefit from participation in several courses per year. The 3,600 employees of State and local agencies therefore have a "training demand" of well over 4,000 exposures per year. In contrast, the FWPCA short-term training program has an exposure capacity of only about 1,000. This resource must, however, also be shared with Federal employees, industrial representatives, and foreign students.

TECHNICIANS

Little effort has been directed toward development of either formal or short-course training programs for water pollution control technicians in past years. This past lack of emphasis can be attributed to the diversity of skills involved and is in part due to the relatively small number of technicians employed by State and local agencies. The increasing use of technicians appears to have great promise for helping correct the present imbalance in the supply of professional employees. Steps can readily be taken to increase both the technician resource pool and skill levels through better use of existing training programs.

Formal training

A new program of technical training for subprofessional skills will be initiated by FWPCA in fiscal year 1968 to help meet the needs of water pollution control technicians. Under this program, training grants will be awarded to technical schools, junior colleges, and similar institutions. The grants will provide funds for teaching staff, equipment, and stipends to trainees. The President's budget for fiscal year 1968 includes $300,000 for this purpose. Awards normally will be made to schools in localities where there are present and future needs for trained technicians and plant operators. This program will provide an opportunity to test and demonstrate the effectiveness of several different types of training programs.

Programs for vocational and technical training administered by other Federal agencies offer substantial opportunities for providing specialized training for technicians. These programs are reviewed in the following five sections:

I. Manpower Development and Training Program

The Federal manpower development and training program (MDTA) provides training for unemployed and underemployed persons in both institutional and on-the-job environments. Financing of institutional training is on a 90-percent Federal and 10-percent State basis. It is estimated that MDTA will train 280,000 unemployed and underemployed personnel at a cost of about $3½ million in fiscal year 1968. Table I in appendix B indicates the training goals for institutional and on-the-job training for adults and youths. Table II in appendix B indicates the distribution of Federal funds and estimated trainees by States for fiscal year 1968.

The MDTA programs, directed toward reducing skill shortages, offer considerable opportunity for training waste treatment plant operators. Using the employment recruiting pattern for most municipal sewage treatment plants today, this program is likely to offer an effective means of upgrading the skills of beginning and partially trained sewage treatment plant operators during the next few years.

The MDTA program will give full consideration in fiscal year 1968 to training in the on-the-job categories where the demand for workers is the greatest. Occupational shortages will be determined at the area level where the training projects are developed and carried out. The selection of the occupations, for which qualified workers are in short supply and in which training can be provided under MDTA, shall be based on the extent to which the shortages exist or are anticipated. The State training plan will reflect the magnitude of the need as well as the occupational distribution. The planning target by the States for this program category is 86,300 workers.

Training for occupations will also be provided through part-time training. The part-time training program is designed to provide relatively short-term training to upgrade the skills of persons already employed. The national goal of 31,000 trainees for part-time training programs in shortage occupations will be carried out through State plans.

A sufficient supply of trained workers for the Nation's increased health programs is one of the most pressing needs and will be a major goal for the MDTA program in fiscal year 1968. Nationally, a goal of 50,000 trained workers for the health occupations has been established. Short-term refresher training and part-time training will be emphasized. To the extent that water pollution control personnel job classifications qualify as health-related occupations, this specially emphasized program will be utilized.

II. Vocctional Education Program

Training in specific occupational categories is offered by vocational education program, administered by the U.S. Department of Health, Education, and Welfare under Public Laws 79–586, 64–347, and 88–210. This program will assist an estimated 6.5 million persons at a Federal cost of $275 million. It is estimated that State contributions will increase this amount to about $850 million.

If municipal treatment plants, industries, and State agencies provide an adequate and attractive labor market to vocational school graduates, a great deal of basic and necessary skill development to meet water pollution control manpower needs can be met through this program.

If State and local water pollution control agencies are to take full advantage of vocational education programs in the various States, it will be necessary to estimate the quantity of manpower and the quality of skills needed at least 2 years in advance.

During fiscal year 1964, 19.2 percent of all high school students were enrolled in some kind of federally aided vocational education program; this increased to 24.6 percent in fiscal year 1965. Projections indicate that by 1970 at least 35 percent of all high school students will be enrolled in federally aided vocational programs.

Post-high school programs are offered in a variety of institutions including area vocational-technical schools, technical institutes, community and junior colleges, and universities. Many States are designating community and junior colleges as area vocational education facilities. A major expansion in course offerings is possible in these facilities.

The Vocational Education Act of 1963 provides for vocational education for adults. This is a relatively new program and many States and localities are experiencing difficulty in obtaining adequate funds to match Federal funds.

Other related Federal programs which offer prejob and on-the-job training and provide an opportunity to meet the needs of water pollution control manpower training requirements are:

A. The vocational rehabilitation program which will provide skilled training to approximately 185,000 persons at an estimated cost of $67 million in fiscal year 1968.

B. The Job Corps which will provide skilled training to an estimated 39,000 in fiscal year 1968.

C. The special skilled programs for minorities which offer substantial opportunity such as the Indian and the Spanish-American vocational training programs.

III. The Community Service and Continuing Education Program

Title 1 of the Higher Education Act of 1965 provides an extremely wide latitude of training and educational activities at subprofessional levels. The sum of $50 million has been authorized and $16.5 million has been requested for fiscal year 1968. The programs in this category for each State are developed by a higher education agency appointed by the Governor. Courses can be established at any accredited public or private college or junior college. The Federal financing of this program has been recommended on a 80–20 matching-fund basis for fiscal year 1968.

In fiscal year 1966, 301 higher education institutions conducted 548 community services programs involving an estimated 14,000 participants.

This program is aimed at the solution of urban and suburban problems. It is anticipated that 85 percent of the effort will be programed toward solving urban and suburban problems in 1968. The Higher Education Act of 1965 identified nine primary problem areas including improvement of local governmental and health services.

During fiscal year 1966, eight of these programs in five States were concerned with air and water pollution at a Federal participation of $181,020. Ohio State University, for instance, provided an instructor training program to improve the level of training for sewage treatment plant operators. South Dakota has used this program for training of sewage treatment plant operators.

IV. Community Development Training Program

The community development training program, administered by the Department of Housing and Urban Development under title 8 of Public Law 88–560, is likely to be of considerable assistance in training State and local government personnel for water pollution control programs. The administration requested $5 million for fiscal year 1968 and the House approved $2.5 million. Representatives from the

Federal Water Pollution Control Administration and from the Department of Housing and Urban Development have discussed possibilities of establishing training programs for State and local government water pollution control personnel.

V. Coordination Activities of Federal Programs Concerned With Education Manpower and Training

In March 1967, the Departments of Health, Education, and Welfare, Commerce, Housing and Urban Development, Labor and the Office of Economic Opportunity established the Cooperative Area Manpower Planning System (CAMPS). The purpose of CAMPS is to develop an effective multiprogram approach to solving the Nation's technical manpower problems. The system provides an opportunity to FWPCA, to each State water pollution control agency, and to each municipal treatment plant to plan its manpower and training needs and to assist in the establishment of training programs that will meet their needs. The CAMP system involves a cooperative venture in the planning and implementation of a nationwide manpower program.

The manpower coordinating committees are established at four levels: area, State, regional, and national. The coordinating committees' primary purposes are: (1) plan a coordinated interagency and intergovernmental program of manpower services and (2) assist in the cooperative implementation of the program.

The system involves the Federal administrators of the major manpower development and related programs. Each has agreed to engage in cooperative planning and implementation of program activities for fiscal year 1968.

A. The agencies presently involved and the programs administered are:

1. Department of Health, Education, and Welfare, Office of Education:
   - (*a*) MDTA institutional training program.
   - (*b*) Adult basic education program.
   - (*c*) Regular vocational and technical education programs.
   - (*d*) Vocational rehabilitation programs.
   - (*e*) Work experience and training program.
   - (*f*) Community work and training program.
2. Office of Economic Opportunity:
   - (*a*) Job Corps program.
   - (*b*) Community action program.
   - (*c*) Migrant and seasonal farmworkers program.
3. Department of Housing and Urban Development:
   - (*a*) Urban planning assistance program.
   - (*b*) Model cities program.
   - (*c*) Neighborhood facilities program.
4. Department of Labor, Manpower Administration:
   - (a) The Employment Service program.
   - (*b*) The national apprenticeship program.
   - (*c*) The manpower development and training program:
     - (1) MDTA institutional training.
     - (2) On-the-job training.
   - (*d*) Neighborhood Youth Corps program.
   - (*e*) Operation Mainstream.

(*f*) New careers program.
(*g*) Special impact program.
(*h*) The concentrated employment program.

5. Department of Commerce, Economic Development Administration:
(*a*) The public works and economic development program.

B. *Area coordinating committees.*—Area coordinating committees will operate within metropolitan centers and other major labor areas. Important functions of the area coordinating committees are—

1. To develop an area manpower plan for fiscal year 1968.
2. To assure effective and timely implementation of approved plans and to make adjustments when necessary.
3. To establish interagency working relationships and to direct applicants to a particular or combination of programs capable of meeting the applicants' needs.

The initial and continuing leadership of the area coordinating committees will come from the State employment security agency.

C. *State coordinating committees.*—The State coordinating committees provide leadership under the direction of the State employment services. The committees are made up of field representatives of Federal agencies and their State counterparts in manpower and human resources programs. Their particular functions are: (1) to develop guides for area committees; (2) to prepare plans for those portions of the State not covered by local committees; (3) to combine all plans into a State plan; and (4) to assist local communities in developing and carrying out a manpower and training program.

D. *Regional coordinating committees.*—The regional coordinating committees are located in the same cities as the regional headquarters of the Bureau of Employment Security. Their primary functions are: (1) to give guidance to State committees; (2) to review and approve State plans in the light of national goals and guidelines; and (3) provide assistance in coordinating the use of available funds by participating agencies.

E. *National coordinating committee.*—The national coordinating committee is established under the leadership of the Manpower Administrator; three of its functions are: (1) to develop annual national manpower goals and guidelines; (2) to find ways and means to develop multiagency cooperative efforts for manpower development; and (3) to provide cooperative funding arrangements.

Short-course training

The remarks under short-term training for professionals are generally applicable to technicians. FWPCA programs are expected to be increasingly directed to technicians employed by State and local agencies. The short-course training programs will have the technical capability of meeting foreseeable needs in this field. However, additional courses may be required.

The opportunity for formal training of water pollution control technicians, if properly developed, appears to be substantially in excess of any foreseeable demand. However, overt action is needed by FWPCA to stimulate the development of courses for these technicians in vocational-technical schools and junior colleges. The FWPCA will provide technical advice and guidance to other Federal agencies in training programs. Future efforts in these fields will have to be carefully balanced to existing needs.

SEWAGE TREATMENT PLANT OPERATORS

The demand for trained sewage treatment plant operators has expanded relatively slowly in the past year (1966–67) and little emphasis has been placed on development of labor pools. Efforts to train operators have also varied widely, ranging from highly successful, well-coordinated programs in some States to the absence of scheduled training in other States. This lack of emphasis on training has been a major factor in the poor quality of operation reported for many sewage treatment plants.

An expanding need for operators and increased public demand for clean waters—effective treatment—indicates the need for a careful reappraisal of all factors related to recruitment, retention, and training of sewage treatment plant operators.

Formal training

The discussion of training opportunities under technicians is generally applicable to sewage treatment plant operators. As noted in that section, a system for planning and implementation of manpower development by various Federal agencies has been initiated. Under this system, each agency has agreed to cooperative planning and implementation of program activities for fiscal year 1968. The programs of the five Federal agencies participating in Cooperative Area Manpower Planning System (CAMPS) are designed to provide a wide range of educational services to unemployed and underemployed persons to prepare them for employment; these Federal programs have a "means" for training many State and local personnel for water pollution control programs.

To take advantage of this cooperative manpower system, the Federal Water Pollution Control Administration has initiated executive level meetings with the Department of Health, Education, and Welfare to identify the job training needs of water pollution control activities throughout the United States. These programs have the potential for filling a major gap in the manpower needs area. In turn, the "graduates" of this program will have an enhanced potential to move into the "plant operator" labor pool.

Short-course training

State agencies have been the most active in organizing training courses or seminars for operators of waste treatment plants. The 1966 Report of the Committee on Personnel Advancement, Water Pollution Control Federation,[1] indicated that 43 States offered one or more technical courses for treatment plant operators. These courses were reported to have reached about 8,000 operators. There is, however, substantial variation in both the type and number of programs offered by the States. These variations reflect, to a degree, the size and technical resources of each State. The State training courses are not ordinarily restricted to plant operators; personnel of other regulatory agencies, consulting engineers, and suppliers are free to attend and participate. Opportunities thereby exist for informal coordination of the training roles of these several groups.

In most areas, the training effort has not been accompanied by improvements in plant operations; this suggests the need for a critical examination of training methods and operator motivation. There is, therefore, a need to evaluate the present effectiveness of training courses in terms of results rather than of the number of students

[1] "1966 Status of Operator Training and Certification in the United States." Journal of the Water Pollution Control Federation, vol. 39, No. 4, 1966.

attending. The Subcommittee on Manpower and Civil Service, House of Representatives, 90th Congress, first session, House Report 329, has noted a similar need in their review of training programs for employees of the Federal Government.

> Evaluation is the one area of training programs that has probably suffered more than any other. Training needs have not always been properly evaluated. Methods of accomplishing training properly have not always been properly evaluated as to the specific objectives desired by the manager sending employees to these courses. Employees' performance on the job is not being properly evaluated in terms of the training which the employee has received, presumably to improve this performance. The committee agrees that evaluation of training is a complex problem. Very few will disagree with this. However, the fact that it is complex is no excuse for not making a reasonable effort to evaluate whether or not the Government is getting a dollar's worth of end product for each dollar it spends on training its employees.

The Water Pollution Control Federation, under the guidance of its committee on personnel advancement, has made a substantial effort to improve the skills of waste treatment plant operators by encouraging the development of State training programs.

The federation has also been a leading force in the development of mandatory as well as voluntary State certification programs and State operator certification programs.

Consulting engineers and professional staff of the suppliers of chemicals and equipment fill an important, though seldom recognized, role in the training of sewage treatment plant operators. Representatives from these firms are in frequent contact with plant operators and representatives of State agencies. They have an unusual opportunity to disseminate information on operational problems, new processes, and new techniques. The important role of these groups must be recognized in future training program developments by encouraging participation in training courses and by providing consulting engineers and suppliers with training aids.

The Missouri Water and Sewerage Technical School at Neosho, Mo., is a convincing example of both the values and potential inherent in joint action. This facility receives direct or indirect financial support from State and local agencies, consulting engineers, suppliers of chemicals and equipment, the Federal Water Pollution Control Administration, and the Department of Labor. It has developed a worldwide reputation for excellence in its intensive, practical courses in operation of waste treatment facilities.

The Federal Water Pollution Control Administration has both a direct and indirect role in short-course training. In its direct role it is concerned with—

1. Encouragement of stronger State training efforts: The Clean Water Restoration Act of 1966 emphasized the importance of including this program element in State programs which are supported in part by program grants. Appropriation authority for program grants will increase from $5 million to $10 million in fiscal year 1968.
2. Direct training courses for operators offered through the FWPCA regional laboratories.
3. Assistance to States in development of training aids.

The FWPCA is indirectly concerned with effectiveness of training efforts as it may influence operations. Many State and Federal water pollution control officials report that most sewage treatment plants are operated well below design levels of effectiveness and that this condition is frequently due to lack of operator training.

Part V. Personnel Utilization and Recruitment

Availability of trained personnel to State and local agencies is influenced by a variety of factors other than simple numbers or training levels. Elements which enter into this aspect of the personnel equation include salary, merit system coverage, job, prestige, and employee productivity.

Salary and merit system coverage

There is reasonably good evidence that many vacancies in State agencies are due to noncompetitive salaries rather than an inherent shortage of adequately trained personnel. Similarly, there is evidence that the poor quality of operation and maintenance of many municipal sewage treatment plants is due to low salary scales, lack of merit system coverage, and a relatively low level of community prestige. During high employment periods, it is impossible to recruit effectively or to retain personnel in positions (State and local) in which salaries and other employee benefits (direct or indirect) are substandard. Training programs will, in fact, have little effect on the availability of personnel if, for example, the new graduate finds that salaries are not competitive, if positions are filled on the basis of patronage rather than merit, or if work at the community sewage treatment plant has a low level of prestige and public acceptability.

Licensing of plant operators

The adoption of mandatory licensing for operators of sewage treatment plants would provide an effective means of upgrading employment conditions for this group of employees. Licensing, on the basis of demonstrated proficiency, has the combined effects of improved plant operations and improved employee stature which provides a better basis for merit system grading of the position. Fifteen States have not adopted mandatory licensing laws.

The following States require licensing of sewage treatment plant operators:

Delaware	New Jersey
Illinois	New York
Indiana	Ohio
Iowa	Oklahoma
Kentucky	Texas
Maryland	West Virginia
Michigan	Wisconsin
Montana	

There are no Federal requirements for mandatory licensing of operators of plants which have been constructed in part with Federal grant funds.

Employee productivity

There appear to be numerous opportunities to upgrade employee productivity at all levels of employment. Some of the steps which can be taken to improve productivity include:

Maximum use of technicians.—States report that they employ an average of only one technician for every six professional employees; however, some States attain a 1 to 1 ratio. Work analysis techniques would help to determine the extent to which technicians might be used to extend the available trained personnel resources.

Job simplification.—Work effectiveness can frequently be improved by specialization of tasks, separation of routine functions, sequencing of job elements, and improved communications. Many industrial techniques should be directly applicable to the waste treatment field.

Design of treatment plants.—Many opportunities exist in designing sewage treatment plants, to reduce the amount of time needed for routine maintenance, and to reduce skill levels required for operation. Additional efforts into this area could pay large dividends in reductions of manpower needs, skilled and nonskilled, for plant operation. Many industries have already demonstrated the results which can be accomplished through application of imaginative approaches.

Continuing statistical needs

Problems encountered in the conduct of this study indicate there is a dearth of information on current and projected employee needs and skills and on employment conditions. There is no readily available information on salaries, length of time required to fill vacancies, or employee turnover rates. Such information would be exceedingly helpful in maintaining a continuing understanding of manpower resources and training problems during the period of rapid expansion of the Nation's clean water efforts.

Pending Federal legislation

Administration bills before the 90th Congress would authorize Government-wide programs which would complement the present and projected activities of the Federal Water Pollution Control Administration in training State and local personnel in the field of water pollution control. The proposed Intergovernmental Manpower Act of 1967 has been introduced as S. 1485 and H.R. 8233. The proposed Intergovernmental Personnel Act of 1967 is similar to the administration's legislation. It has been introduced as S. 699, H.R. 4987, H.R. 5800, and H.R. 8070.

The administration's legislation seeks to strengthen State and local personnel systems through—

The admission of State and local personnel to Federal training programs.

The training of State and local personnel, whose responsibilities relate to Federally assisted programs, either in Federal training programs or in State and local training and education programs with Federal support.

Grants to States and local governments for personnel training and education programs.

Grants to States and local agencies for government service fellowships for State and local government personnel.

Grants and technical assistance to strengthen State and local personnel systems.

Cooperative Federal-State and Federal-local recruitment and examination activities.

Encouragement of interstate compacts strengthening State and local personnel systems.

Interchange of employees between the Federal Government and the States and between the Federal and local governments.

Coordination of various Federal training programs under the leadership of the Civil Service Commissioner.

And extension of merit system coverage to State and local employees as a requirement of Federal grant assistance, to the extent that the President determines this to be practicable.

Part VI.—Conclusions and Corrective Actions

The preventive and corrective actions to be undertaken or already underway by the Federal Water Pollution Control Administration are based on several conclusions regarding the current and projected needs for trained manpower by State and local agencies. Available data on manpower needs and training resources indicate that—

1. Total industry and government demands for engineers and scientists will probably exceed the supply for the next several years. This general situation will require that the water pollution control programs, like all other elements of industry and government, examine current employment needs and personnel utilization practices to assure that the most effective use is made of available trained manpower.

2. Educational programs supported by FWPCA and OWRR are making a substantial contribution to the supply of highly trained specialists in the water resources and water pollution control fields. These programs should accelerate in future years to supply an adequate cadre of highly trained specialists. The ability of State and local agencies to recruit and retain graduates of these programs will be influenced by their personnel systems.

3. There is a continuing need for upgrading and updating of professional skills through short-course training.

4. Greater use can be made of technicians. There are many Federal programs with great potential for increasing the numbers of technicians trained in the clean water field.

5. Existing programs for the training of sewage treatment plant operators are inadequate in both quantity and quality. In addition, retention of trained operators will be influenced by such factors as salary levels, merit system coverage, and mandatory licensing requirements.

6. There are many opportunities for application of technology and management practices which would increase employee productivity and thereby help to reduce needs for trained manpower.

FWPCA will take the following actions to assure that there will be adequate training opportunities for State and local personnel employed in the clean water field and that there will be an adequate reservoir of trained personnel to—

1. Continue the orderly expansion of the FWPCA grant programs which provide financial support for the training of graduate students in the specific water pollution control disciplines. It is anticipated that this grant program will be initiated in fiscal year 1968 to provide support to vocational schools and junior colleges for the training of technicians and sewage treatment plant operations.

2. Encourage and assist States in placing greater emphasis on the training aspects of their own programs. The increased appropriations which are expected to be available for State grants in fiscal year 1968 should assist them in development of improved programs.

3. Expand the present short-course training programs which have been offered at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Beginning in fiscal year 1968, courses will be offered at Federal water pollution control laboratories at Corvallis, Oreg.; Cincinnati, Ohio; College, Alaska; Ada, Okla.; Athens, Ga.; and Metuchen, N.J. A wider range of technical subjects will also be offered, including training courses for operations of sewage treatment plants. The training program will also be expected to make a greater contribution to State efforts through the development of training aids.

4. Develop a cooperative governmentwide education and training program which will make full use of other existing federally assisted programs for developing professional and vocational skills. The FWPCA has initiated executive level discussions with the Department of Health, Education, and Welfare to find ways for directing appropriate efforts into the clean water field.

5. Seek to improve the stature and conditions of employment for operators of municipal waste treatment plants through extension of State and local merit systems and mandatory licensing for operators. The opportunities for improved plant operation inherent in the licensing procedure are so great that it may be necessary to seek suitable amendments to the construction and State-grant sections of the Federal Water Pollution Control Act to require mandatory licensing for operators of plants constructed with Federal funds.

6. Undertake, support, and encourage research and development efforts to improve employee productivity. These efforts might include such activities as—

(*a*) To review the design of sewage treatment plants and pumping stations to minimize maintenance needs and to reduce the skill levels required for operation.

(*b*) To undertake management studies of employee utilization at all levels of the clean water programs to determine how current employees are utilized and to seek maximum use of technicians.

(c) To seek increased use of automation in the design of sewage treatment plants, in sample collection and analysis, in data collection and analysis, and in the operation of sewage treatment plants.

The Federal Water Pollution Control Administration has recognized the importance of a continuing coordinated effort in this field and has established on Office of Manpower and Training. This Office will guide, coordinate, and schedule the various FWPCA programs which are concerned with manpower and training and will serve as a focal point for contacts with other agencies. The Office will also be responsible for the establishment of objectives for training programs and for the stimulation of technical and management research and development projects aimed at increased employee productivity.

The Federal Water Pollution Control Administration is also aware of current legislative proposals dealing with State and local manpower problems. If the current legislative proposals dealing with intergovernmental manpower are enacted, the FWPCA would expect to work with the Civil Service Commission and other appropriate Federal agencies in the development of procedures for utilizing the new authority to strengthen State and local government personnel and training programs.

APPENDIX A

SOURCES OF DATA

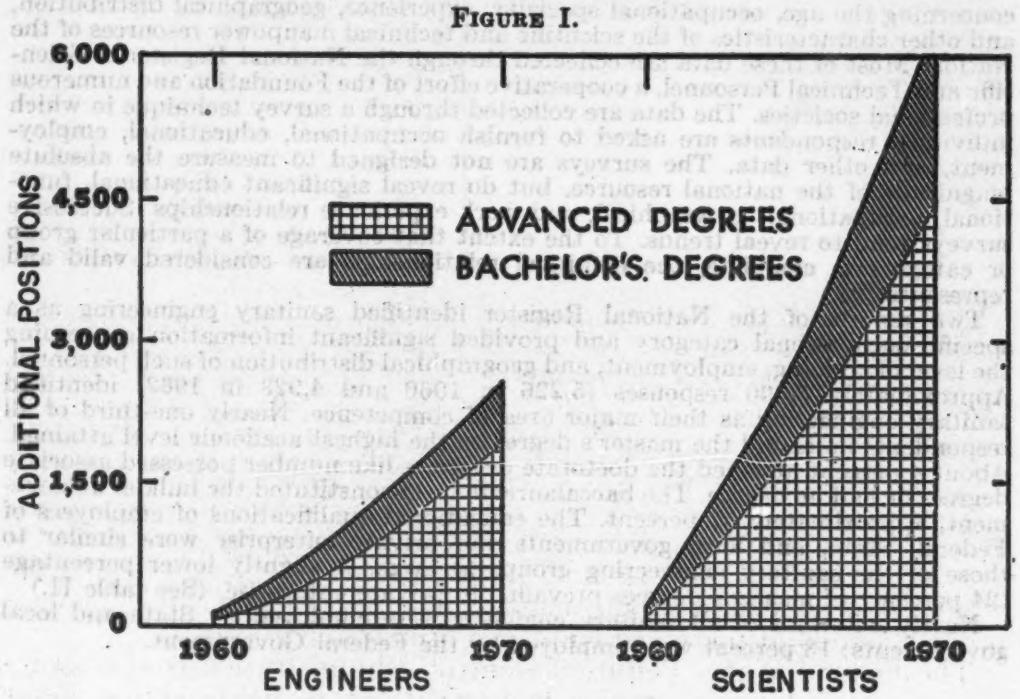
Report of the Committee on Environmental Health Problems

This report,[1] prepared by the Public Health Service in 1962, included the first highly specific analysis of needs for water pollution control manpower. The Committee concluded that the national water supply and pollution control effort would require an additional 6,000 engineers and 15,000 allied scientists during the period 1961–70. Inclusion of the 1961 immediate employment needs of 2,000 engineers and 2,000 scientists would increase the 1970 water pollution control manpower demand to 8,000 engineers and 17,000 scientists.

The Committee also concluded that the level of training of water pollution control personnel would need to be quite high. Approximately 71 percent of both engineers and scientists were estimated to require advanced degrees. The Committee's estimates for additional personnel are presented in figure I.

The Committee's estimates include both water supply and water pollution control manpower requirements. The Committee also estimated the 1970 distribution of water supply and pollution control manpower among various sectors of employment. The distribution is summarized in table I. The projected distribution was based upon several empirical relationships which are presented as footnotes to the table. The Committee did not project the manpower requirements of engineering consultants or supply firms.

FIGURE I.



[1] Report of the Committee on Environmental Health Problems, 1962, PHS Publication No. 908.

TABLE I.—DISTRIBUTION OF NATIONAL EFFORT BASED ON MANPOWER NEEDS BY 1970

	Engineers	Scientists	Total
States [1]	2,300	2,300	4,600
Municipalities [2]	2,800	2,800	5,600
Industries [3]	3,000	3,000	6,000
Universities [4]	300	700	1,000
Federal [5]	1,000	3,000	4,000
Total	9,400	11,800	21,200

[1] 1 engineer plus 1 scientist/100,000 population (1970 population)=230,000,000.
[2] 1 engineer plus 1 scientist/50,000 urban population (1970 urban population)=143,000,000.
[3] 1 out of 3 wet-process industries having separate discharge require 1 engineer and 1 chemist.
[4] 1959 faculty, student output, and manpower need projections.
[5] Present staff in other Federal agencies and on specific study of needs by Water Pollution Advisory Board in 1961.
Source: Report of the Committee on Environmental Health Problems, 1962.

The Committee did not analyze the needs for water supply and pollution control scientists according to academic discipline or occupational classification, nor did it analyze the current (1961) character of water pollution control employment.

The Committee's conclusion, that a significant and pressing demand for water supply and pollution control engineers and scientists would develop, has been substantiated.

It should also be emphasized that the Committee's estimates were based primarily upon the volume of water pollution work which would be generated by population growth and industrial development and did not consider changes in its character.

National Science Foundation reports

The National Science Foundation collects, analyzes, and disseminates data concerning the age, occupational specialty, experience, geographical distribution, and other characteristics of the scientific and technical manpower resources of the Nation. Most of these data are collected through the National Register of Scientific and Technical Personnel, a cooperative effort of the Foundation and numerous professional societies. The data are collected through a survey technique in which individual respondents are asked to furnish occupational, educational, employment, and other data. The surveys are not designed to measure the absolute magnitude of the national resource, but do reveal significant educational, functional, occupational, geographical, and work experience relationships. Successive surveys tend to reveal trends. To the extent that coverage of a particular group or category is complete, the empirical relationships are considered valid and representative.

Two reports of the National Register identified sanitary engineering as a specific occupational category and provided significant information concerning the level of training, employment, and geographical distribution of such personnel. Approximately 5,000 responses (5,226 in 1960 and 4,923 in 1962) identified sanitary engineering as their major area of competence. Nearly one-third of all respondents indicated the master's degree as the highest academic level attained. About 4 percent attained the doctorate degree, a like number possessed associate degrees or had no degree. The baccalaureate level constituted the bulk of achievement, approximately 57 percent. The educational qualifications of employees of Federal, State, and local governments and private enterprise were similar to those of the sanitary engineering groups at large. A slightly lower percentage (24 percent) of master's degrees prevailed in private enterprise. (See table II.)

Nearly one-third of all sanitary engineers were employed by State and local governments; 13 percent were employed by the Federal Government.

TABLE II.—SELECTED CHARACTERISTICS OF SANITARY ENGINEERING MANPOWER

	1960 (percent)	1962 (percent)
Level of Training:		
Less than bachelor	4.6	3.5
Bachelor	58.4	56.1
Master	32.0	33.8
Ph. D	4.1	4.6
No report, other	.9	2.0
Employer:		
Educational institutions	6.6	7.4
Federal Government	5.2	6.1
State and local governments	32.4	33.4
Military and Public Health Service	8.2	7.4
Nonprofit organizations	1.0	.7
Industry, business, self-employed	43.2	41.6
No report, other	3.4	3.4
Geographical distribution:		
Selected States	51.9	55.7
California	9.9	10.4
New York	9.9	10.4
Pennsylvania	6.0	5.9
New Jersey	2.8	2.9
Texas	1.2	4.3
Illinois	6.4	6.4
Ohio	6.0	6.2
Massachusetts	3.6	3.4
Michigan	3.7	3.6
Maryland	2.4	2.2
Other locations	49.1	44.3

Sources: American Science Manpower, 1960, National Science Foundation 62-43; American Science Manpower, 1962 National Science Foundation 64-16.

Forty-two percent were employed by private, profitmaking enterprise, and 7 percent by educational institutions. (See table II.)

Staffing and budgetary guidelines for State water pollution control agencies; Public Administration Service, 1965

The staffing requirements of State water pollution control agencies were analyzed by the Public Administration Service under a contract with the predecessor agency of the Federal Water Pollution Control Administration. The results of this study were published in the Journal of the Water Pollution Control Federation and have received wide circulation.[2]

Staffing estimates were derived for both general program support (general administration, legal services, water quality surveillance, project and program service) and facilities service (visitation and inspection of treatment facilities). The estimates included all professional, technical, and supporting staff—including clerical help. It was estimated that a professional/technician staff ratio of 31 percent would be realistic. However, the authors pointed out that the actual ratio in 13 States ranged from 15 to 51 percent.

An estimate of the general program requirements was based on four criteria believed to correlate with staffing requirements: State population, land area of the State, recreational water use, and industrial water use. The criteria and indicators were then weighted using a point system designed to indicate the relative—needs of States grouped in six major classes according to 1960 population. Estimates of the minimum and desirable staffing requirements of States grouped in population classes were derived by consultation with responsible administrators in 13 States. Also, point scores were derived for each State. The basic staffing requirement was assumed to apply to the median State of each class and the minimum and desirable estimates for other States were prorated, based on point scores.

Estimates of the facilities service requirements were also made. These estimates were added to those for general program support, and rounded upward to determine total requirements.

The authors also indicated that special regional problems might require additional staff. Accordingly, the estimates are considered conservative at least on a national basis.

[2] Staffing and Budgetary Guidelines for State Water Pollution Control Agencies, T. R. Jacobi, R. A Pavia, and E. F. Ricketts; Journal of the Water Pollution Control Federation, vol. 37, No. 1 (January 1965).

The staffing estimates were based on indicators of water pollution control workload and were independent of organizational and governmental structure. In States where water pollution control activities are performed by several agencies (the report states that this practice predominated), the estimates might need to be increased.

The report did not attempt to define an optimum distribution of professional disciplines. No discernible relationship was found between disciplinary requirments and agency needs, as determined by the workload criteria.

Summation of the individual State estimates gives a national estimate of approximately 4,000 authorized positions of which 69 percent, or 2,760, would constitute professional staff.

Estimation of plant operators

Only one estimate of the need for wastewater treatment plant operators has been prepared and published. This estimate[3] was based on staffing recommendations of the Conference of State Sanitary Engineers and on projections of the population to be served by treatment facilities.

The study predicted man-years of operation required in plants serving various sizes of population. In the smaller population classes fractional estimates were made. Since estimates of man-years of operation do not always correlate with the number of employees required, the indicated needs are considered conservative. Also, the recommendations of the Conference of State Sanitary Engineers were intended to indicate minimum staffing requirements, not necessarily those which would encourage more efficient operation.

The estimates did not include requirements for operation of sewage treatment plants at Federal facilities.

ASSESSMENTS OF TRAINING NEEDS

These studies are concerned primarily with the qualitative aspects of manpower management and development, including the capacity and efficiency of training programs.

Professional training

The "Graduate Register of Programs in Sanitary Engineering" prepared jointly by the Environmental Engineering Intersociety Board and the American Association of Professors of Sanitary Engineering provides comprehensive data on professional training for engineers in water pollu tion control. This report was especially prepared to serve as a guide in assessing and planning advanced training programs in sanitary engineering. Information was confined to the graduate programs of 56 educational institutions having two or more full-time sanitary engineering faculty located in a department of engineering.

The 1965 graduates of the 56 programs obtained 300 advanced degrees (290 masters and 10 doctors). Approximately 96 percent of these were specialists in water supply or pollution control technology. The rate of increase (1960–65) of graduate degrees awarded in clean water specialties has been approximately twice that for all fields of engineering. Of all students receiving financial support, 35 percent received support from Federal sources. This percentage is also about twice that for all fields of engineering.

The majority of the degrees awarded in water-oriented specialties were believed to be in engineering; however, the report emphasized that the percentage of non-engineering degrees is increasing.

Since 1960, program capacities and sanitary engineering faculties have increased drastically, presumably as a result of Federal support. There are now at least 239 faculty members teaching courses in the conventional field of sanitary engineering, of which 83 percent specialize in water quality and treatment.

Educational capacity seems to be concentrated in limited geographical areas. Of the 56 programs reporting, 29 were located in 10 States. Eighteen States still do not possess a graduate program in sanitary engineering.

Operator training

The "1966 Report of the Committee on Personnel Advancement of the Water Pollution Control Federation"[4] constitutes the major analysis of waste water treatment plant operator training. This report provides data on operator training programs in the United States. In 16 States either no program exists or no data

[3] "Need for Operators Estimated," Highlights, Water Pollution Control Federation, vol. 3, No. 9, July 1966.
[4] Journal, Water Pollution Control Federation, April 1967.

were submitted. Information provided includes a description of the duration and level of program, texts used, sponsors and conducting groups, latest course attendance, fee requirements, and special remarks. The programs varied from a 144-hour annual offering to fifteen 1-hour sessions offered once each week for 15 weeks. A 2- or 3-day annual course predominated. Sixteen different manuals, texts, or special notes were used in offering these courses. The basic Manuals of Practice of the Water Pollution Control Federation, New York State, and the State of Texas predominated. Attendance at courses ranged from 14 to 848. Total attendance at all courses was 7,889, but this included persons attending more than one course and, in some cases, water plant operators. In 31 of the courses, water works personnel were included. Examinations were given in 41 courses.

APPENDIX B

LIST OF PUBLIC LAWS AUTHORIZING FEDERAL TRAINING PROGRAMS

The following list identifies 37 public laws or parts thereof which authorize Federal assistance to provide job-oriented education and training to prepare people for employment. They can be summarized under the following classifications:

Training programs by public law categories:	*Number of public laws in each program/category*
Higher education and professional training	21
Assistance to group with special needs	7
Occupational training	4
Alleviation of poverty	2
Vocational education	3
Total	37

HIGHER EDUCATION AND PROFESSIONAL TRAINING

	Public Law
Act of November 2, 1921, authorizing the provision of educational programs for Indians	67–856
Atomic Energy Commission Act of 1954, sec. 31(a)	83–703
Civil Rights Act of 1964, sec. 404	88–352
Clean Air Act, 1963, sec. 3	88–206
Departments of Labor, and Health, Education, and Welfare Appropriation Act, 1965	88–605
Graduate Public Health Training Amendments of 1964, amending sec. 306 of the Public Health Service Act	88–497
Health Professions Educational Assistance Act of 1963, as amended by Loans to Students of Optometry Act, Public Law 88–654	88–129
Juvenile Delinquency and Youth Offenses Control Act of 1961, as amended by Public Laws 88–368 and 88–[illegible]	87–274
Mental Retardation Facilities and Community Mental Health Centers Construction Act of 1963, title III	88–164
Mutual Education and Cultural Exchange Act of 1961 (Fulbright-Hayes)	87–256
National Aeronautics and Space Administration Act of 1958	85–568
National Defense Education Act of 1958, as amended by Public Laws 87–344, 88–210, and 88–665	85–864
National Science Foundation Act of 1950, as amended by Independent Offices Appropriation Act, 1964, Public Law 88–215	81–507
Nurse Training Act of 1964, which adds title VIII to the Public Health Service Act	88–581
Program for training teachers of the deaf	87–276
Public Health Service Act, 1944, as amended	78–410
Program for preparation of professional personnel in education of handicapped children, as amended by Public Law 88–164	85–926
Social Security Act, 1935, title V, as amended by Public Law 87–543	74–271
Water Pollution Control Act Amendments of 1956, sec. 4(a)(2)	84–660
Housing Act of 1964, title VIII	88–560
Higher Education Act of 1965, title I	89–329

ASSISTANCE TO GROUPS WITH SPECIAL NEEDS

Adult Indian Vocational Training Act, as amended by Public Laws 87–273 and 88–230	84–959
Federal Prison Industries, Inc., Act of 1934, as amended by Public Law 88–245	73–461
Migration and Refugee Assistance Act of 1962	87–510
Veterans Readjustment Assistance Act of 1952	82–550

ASSISTANCE TO GROUPS WITH SPECIAL NEEDS—continued

	Public Law
Veterans Vocational Rehabilitation Act of 1943, as amended by Public Laws 81–894, 83–610, 86–721, 87–591, and 87–815	78–16
Vocational Rehabilitation Act of 1920, as amended by Public Laws 83–565, 84–896, 86–70, and 86–624, sec. 4	66–236
War Orphans Educational Assistance Act of 1956, as amended by Public Laws 85–460, 86–785, and 88–361	84–634

OCCUPATIONAL TRAINING

Area Redevelopment Act, 1961	87–27
Manpower Development and Training Act of 1962, as amended by Public Laws 87–729, 88–214, and 89–15	87–415
National Apprenticeship Act of 1937	75–308
Trade Expansion Act of 1962	87–794

ALLEVIATION OF POVERTY

Economic Opportunity Act of 1964	88–452
Social Security Act, sec. 409 and sec. 1115, as amended	74–271

VOCATIONAL EDUCATION

George-Barden Act of 1946	79–586
Smith-Hughes Act of 1917	64–347
Vocational Education Act of 1963	88–210

TABLE I.—NATIONAL MANPOWER DEVELOPMENT AND TRAINING ACT TRAINEE PLANNING GOALS BY PROGRAM COMPONENT—FISCAL YEAR 1968

The Secretary of Labor enters into agreements with the States to provide weekly cash allowances to employed persons in training and to inadequately trained youths who require an allowance if they are to undertake training.

The Secretary of Health, Education, and Welfare enters into agreements with State vocational education agencies to provide occupational training, and with other education agencies to provide basic education as preparation for occupational training.

Training is administered under this program by the Office of Manpower, Automation and Training, Manpower Administration, Department of Labor and by the Bureau of Education Assistance Programs, Office of Education, Department of Health, Education, and Welfare.

The following table reflects the significance and potential of this program:

Program components	Total trainees	Disadvantaged trainees			Regular adults
		Total	Adults	Youth	
Total [1]	280,000	179,400	[2] 111,800	67,600	[2] 100,600
Institutional and other	163,000	[3] 103,600	[4] 52,000	51,600	59,400
Regular institutional	112,000	83,600	42,000	41,600	28,400
Part time	31,000				31,000
Other than skill	20,000	20,000	10,000	10,000	
On-the-job training	112,000	[3] 70,800	[4] 54,800	16,000	41,200
Coupled	64,000	36,900	28,400	8,500	27,100
Noncoupled	48,000	33,900	26,400	7,500	14,100
Inmates	5,000	5,000	5,000	[5]	

[1] Includes 13,700 trainees in redevelopment area (sec. 241) projects.
[2] Older workers (45 years or older) should comprise 24.9 percent of all trainees budgeted as adults.
[3] 14.8 percent of disadvantaged trainees (excluding redevelopment area projects and inmates) are to be welfare recipients.
[4] 14.8 percent of disadvantaged "adult" trainees (excluding redevelopment area projects and inmates) are to be Neighborhood Youth Corps graduates.
[5] Inmates are budgeted and shown as "adults," even though young inmates are to be trained.

Source: National Manpower and Related Program Goals—Fiscal Year 1968, Interagency Cooperative Issuance No. 3, Attachment II issued by Cooperate Manpower Planning Section, April 3, 1967.

TABLE II.—NATIONAL MANPOWER AND TRAINING ACT [1]

ESTIMATED STATE APPORTIONMENT OF FUNDS AND ESTIMATED NUMBERS OF TRAINEES FISCAL YEAR 1968

[All dollar figures in thousands]

States	Institutional and other training		MDTA programs for on-the-job training	
	Federal funds [3]	Trainees [3]	Federal funds	Trainees [3]
United States	$178,000	130,300	$82,000	86,300
Alabama	2,456	1,800	1,132	1,190
Alaska	409	300	189	200
Arizona	1,371	1,000	631	660
Arkansas	1,584	1,160	730	770
California	26,771	19,600	12,333	12,980
Colorado	1,762	1,290	812	850
Connecticut	2,545	1,860	1,173	1,230
Delaware	409	300	189	200
District of Columbia	783	570	361	380
Florida	3,168	2,320	1,460	1,540
Georgia	2,937	2,150	1,353	1,420
Guam	36	30	16	20
Hawaii	534	390	246	260
Idaho	730	530	336	350
Illinois	9,220	6,750	4,248	4,470
Indiana	3,222	2,360	1,484	1,560
Iowa	2,261	1,650	1,041	1,100
Kansas	2,029	1,490	935	980
Kentucky	2,723	1,990	1,255	1,320
Louisiana	2,759	2,020	1,271	1,340
Maine	641	470	295	310
Maryland	2,456	1,800	1,132	1,190
Massachusetts	6,479	4,740	2,985	3,140
Michigan	6,889	5,040	3,173	3,340
Minnesota	3,044	2,230	1,402	1,480
Mississippi	1,709	1,250	787	830
Missouri	3,934	2,880	1,812	1,910
Montana	623	460	287	300
Nebraska	1,317	960	607	640
Nevada	552	400	254	270
New Hampshire	481	350	221	230
New Jersey	7,262	5,320	3,345	3 520
New Mexico	712	520	328	350
New York	20,061	14,680	9,241	9,730
North Carolina	3,329	2,440	1,533	1,610
North Dakota	801	590	369	390
Ohio	8,402	6,150	3,870	4,070
Oklahoma	1,691	1,240	779	820
Oregon	1,833	1,340	845	890
Pennsylvania	9,416	6,890	4,338	4,570
Puerto Rico	2,403	1,760	1,107	1,170
Rhode Island	765	560	353	370
South Carolina	1,976	1,450	910	960
South Dakota	659	480	303	320
Tennessee	2,919	2,140	1,345	1,420
Texas	6,960	5,090	3,206	3,370
Utah	1,104	810	508	540
Vermont	392	290	180	190
Virginia	2,510	1,840	1,156	1,220
Virgin Islands	36	30	16	20
Washington	3,008	2,200	1,386	1,460
West Virginia	1,353	990	623	660
Wisconsin	4,236	3,100	1,952	2,050
Wyoming	338	250	156	160

[1] Source: National Manpower and Related Program Goals, fiscal year 1968, Interagency Cooperative Issuance No. 3, attachment II, issued by Cooperate Manpower Planning Section, April. 3, 1967.

[2] Out of these funds, $158,000,000 is for regular, institutional training which requires State matching funds.

[3] Numbers rounded to nearest 10.

TABLE III.—VOCATIONAL EDUCATION ACT[1]

Funding plan for fiscal year 1968:	*1968 estimate*
1. Vocational Education Act of 1963:	
(a) Vocational training	$138,736,000
(b) Construction of area vocational education facilities	60,573,000
2. George-Barden and supplemental acts:	
(a) George-Barden Act:	
(1) Practical nurse training	5,000,000
(2) Area vocational training	15,000,000
(3) Other vocational training	29,686,000
(b) Supplemental acts	305,000
3. Appalachian regional development	15,000,000
4. Student aid:	
(a) Insured loans:	
(1) Advances for reserve fund	----------
(2) Interest payments	3,600,000
(b) Work-study programs	----------
Total	267,900,000

[1] Source: National Manpower and Related Program Goals, fiscal year 1968, Interagency Cooperative Issuance No. 3, attachment II, issued by Cooperate Manpower Planning Section, Apr. 3, 1967.

NATIONAL VOCATIONAL EDUCATION PROGRAM[1]

	1965 actual	1966 actual	1967 estimated	1968 estimated
High school programs	$2,819,250	$3,169,709	$3,500,000	$3,920,000
Post-high school programs	207,201	442,451	525,000	552,000
Adult programs	2,378,522	2,544,962	2,700,000	2,856,000
Special needs programs	25,638	59,557	155,000	175,000
Total	5,430,611	6,216,679	6,880,000	7,503,000

[1] Source: National Manpower and Related Program Goals, fiscal year 1968, Interagency Cooperative Issuance No. 3, attachment II, issued by Cooperate Manpower Planning Section, Apr. 3, 1967.

APPENDIX C

PART 1. SCHEDULE OF COURSES OFFERED DURING FISCAL YEAR 1967 AT THE FEDERAL WATER POLLUTION CONTROL ADMINISTRATION LABORATORIES

THE ROBERT S. KERR WATER RESEARCH CENTER, ADA, OKLA.

Water quality studies	July 25–Aug. 5, 1966.
Marine biology in water pollution studies	Apr. 17–28, 1967.

THE SOUTHEAST WATER LABORATORY, ATHENS, GA.

Introduction to radioactive safety	Jan. 31–Feb. 3, 1967.

THE ROBERT A. TAFT SANITARY ENGINEERING CENTER, CINCINNATI, OHIO

Interference organisms in water supplies	July 11–15, 1966.
Chemical analyses for water quality	Aug. 15–26, 1966; Jan. 16–27, 1967.
Water quality studies	Sept. 12–23, 1966.
Plankton analysis	Oct. 10–21, 1966.
Membrane filter techniques in water bacteriology.	Nov. 14–18, 1966.
Biooxidation of industrial wastes	Dec. 5–16, 1966.
Current practices in water microbiology	Feb. 6–17, 1967.
Data handling in water pollution control—operation and use of the storet system.	Mar. 6–10, 1967.
Biological studies in water pollution control	Mar. 13–15, 1967.
Pesticides in the environment	Apr. 17–28, 1967.
Laboratory analyses for waste water treatment plant operators.	May 8–19, 1967.
Aquatic biology for engineers	June 5–16, 1967.
Orientation to automated instrumentation for water pollution surveillance.	June 19–23, 1967.

PACIFIC NORTHWEST WATER LABORATORY, CORVALLIS, OREG.

Data handling in water pollution control—Storet	Aug. 23, 1966.
Data handling in water pollution control—Storet	Aug. 24–25, 1966.
Data handling in water poliution control—Storet	Sept. 13–14, 1966.
Current practices in water microbiology	Feb. 27–Mar. 10, 1967.
Water quality studies	Apr. 3–17, 1967.
Biological studies in water pollution control	May 2–4, 1967.

PART 2. SCHEDULE OF COURSES OFFERED DURING FISCAL YEAR 1968 AT FEDERAL WATER POLLUTION CONTROL ADMINISTRATION LABORATORIES

THE ROBERT S. KERR WATER RESEARCH CENTER, ADA, OKLA.

Chemical analyses for water quality	Sept. 18–29, 1967.
Applications of biological principles in water pollution control.	Nov. 6–8, 1967.
Water quality studies	Nov. 27–Dec. 8, 1967.
Geohydrologic relationships in water pollution	Jan. 22–26, 1968.
Pollution problems related to ground water	Jan. 29–Feb. 2, 1968.
Data analysis and evaluation in water pollution studies.	Feb. 26–Mar. 1, 1968.
Fresh water biology and pollution ecology	Mar. 25–Apr. 5, 1968.
Fresh water pollution ecology	Apr. 1–5, 1968.
Current practices in water microbiology	May 6–17, 1968.

THE SOUTHEAST WATER LABORATORY, ATHENS, GA.

Analysis of pesticides in the aquatic environment.	Jan. 22–Feb. 2, 1968.
Data analysis and evaluation in water pollution studies.	Apr. 8–12, 1968.
Marine biology and pollution ecology [1]	Apr. 29–May 10, 1968.
Marine pollution ecology [1]	May 6–10, 1968.
Applications of biological principles in water water pollution control.	May 13–15, 1968.
Water quality studies	June 17–28, 1968.
Seminar on water pollution control problems	Through special arrangement with the Water Laboratory.

[1] At a field location to be announced later by the Water Laboratory.

THE ROBERT A. TAFT SANITARY ENGINEERING CENTER, CINCINNATI, OHIO

Plankton analysis for treatment plant operators.	July 10–14, 1967.
Water quality studies	July 24–Aug. 4, 1967.
Chemical analyses for water quality	Aug. 14–25, 1967.
Statistical method-evaluation and quality control for the laboratory.	Aug. 28–Sept. 1, 1967.
Seminar on the FWPCA: Structure and functions.	Sept. 27–29, 1967.
Freshwater biology and pollution ecology	Oct. 9–20, 1967.
Freshwater pollution ecology	Oct. 16–20, 1967.
Laboratory analyses for treatment plant operators.	Oct. 23–Nov. 3, 1967.
Physical-chemical treatment of wastewaters and sludges.	Dec. 4–15, 1967.
Current practices in water microbiology	Jan. 8–19, 1968.
Applications of biological principles in water pollution control.	Jan. 22–24, 1968.
Orientation to automated instrumentation in water pollution surveillance.	Jan. 29–Feb. 2, 1968.
Biological treatment of wastewaters and sludges.	Feb. 5–16, 1968.
Freshwater pollution ecology	Feb. 26–Mar. 1, 1968.
Analysis of pesticides in the aquatic environment.	Mar. 4–15, 1968.
Membrane filter methods for treatment plant operators.	Mar. 18–22, 1968.
Statistical method-evaluation and quality control for the laboratory.	Do.
STORET system for data handling in water pollution control.	Mar. 25–29, 1968.
Laboratory analyses for treatment plant operators.	Apr. 1–12, 1968.
Chemical analyses for water quality	Apr. 22–May 3, 1968.
Plankton analysis	June 3–14, 1968.
Operation of automated instrumentation in water pollution surveillance.	Date to be announced.
Basic principles of wastewater treatment operation.	Do.
Seminar on water pollution control	Through special arrangement with the water laboratory.

ALASKA WATER LABORATORY COLLEGE, ALASKA

During fiscal year 1968, a limited number of water pollution control training courses may be arranged for presentation in Alaska through the Alaska Water Laboratory College, Alaska, by contracting the chief of training at the laboratory.

THE PACIFIC NORTHEST WATER LABORATORY CORVALLIS, OREG.

Membrane filter methods for treatment plant operators.	Sept. 11–15, 1967.
Water quality studies	Oct. 9–20, 1967.
Laboratory analyses for treatment plant operators.	Nov. 6–17, 1967.
Chemical analyses for water quality	Jan. 8–19, 1968.
Freshwater biology and pollution ecology	Mar. 4–15, 1968.
Marine biology and pollution ecology	May 6–17, 1968.
Marine pollution ecology	May 13–17, 1968.

THE NORTHEAST REGION PROJECT OFFICE, METUCHEN, N.J.

Water quality studies	Sept. 11–22, 1967.
Chemical analyses for water quality	Nov. 6–17, 1967.
Current practices in water microbiology	Feb. 5–16, 1968.
Seminar on water pollution control problems	Through special arrangement with the water laboratory.

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